UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

January 22, 2009

Keith D. Roberts
Manger, Environmental Sites
Environmental Remediation
Olin Corporation
3855 North Ocoee Street, Suite 200
Cleveland, TN 37312

RE: January 28 Meeting, Olin Corp./McIntosh Plant OU-2

Dear Mr. Roberts:

EPA is hereby submitting materials in preparation for the January 28, 2009 meeting to discuss tasks to be completed and the strategic path forward for Olin Corporation McIntosh Plant OU-2, based on the working schedule drafted in November 2008. In preparation for the meeting, EPA has developed the following documents, included as attachments to this letter:

1) Agenda for the January 28 Olin OU-2 Meeting

2) EPA Review of Olin OU-2 Historical Documents for the Purposes of Identifying Uncertainties and Data

3) Analysis of 2008 Olin Storm Water Sampling Data for Select Locations in OU-2, dated December 3, 2008

4) Evaluation of the Monitored Natural Recovery Concept for the Olin OU-2 Site, dated October 27, 2008

EPA looks forward to continuing to work with the Olin team to discuss and resolve outstanding issues in a timely manner, and to continue making progress on this important site.

Should you have any questions, please feel free to contact me at (404)562-8814.

Sincerely,

Beth Walden

Beth Walden
Remedial Project Manager

Attachments

Olin Path Forward Meeting Jan 28, 2009

AGENDA (updated Jan 22, 2008)

Wed, Jan 28 (8:30 to 17:00)

1. Introduction and objectives for meeting *30 min*
   - *Reach agreement on strategy to achieve ROD*
   - *Review current and historical data and reports*
   - *Identify data gaps and uncertainties*
2. Olin Updates *60 min*
   - ESPP flood events and related sampling
   - GW results and CSM

Break 15 min

3. EPA's list of areas of agreement *30 min*
4. EPA's list of areas where further data collection/analysis may be needed to reach agreement (See page 2) *30 min*
5. EPA's proposed strategy (See Page 3): *60 min*

Working Lunch

6. Presentation and discussion of EPA's review of RI, Eco Risk and RGO documents *60 min*
   - Nature and extent (issues, uncertainties)
   - Human health risk (issues, uncertainties)
   - Ecological risk (issues, uncertainties)
   - Remedial goals (issues, uncertainties)

Break 15 min

7. Presentation and discussion of EPAs review of FS and evaluation of dredging as an alternative *90 min*
8. Discuss path forward, specific action items, milestones and schedule *45 min*

Points of Current Agreement

- Unacceptable ecological risk, remediation required at least in the basin
- Contaminants of concern: mercury, DDTr, HCB
- Groundwater pathway not significant input to the Tombigbee River
    - Still need to see data to confirm
- Methylation process critical to bioavailability of mercury to food chain
- ESPP and active capping alternatives should be considered fully and evaluated in the FS addendum
- Rather than rewrite all historical reports (RI, eco risk assessment, RGO sampling support, FS), one RI addendum and a streamlined FS will be developed to support remedial decision making.

Points that May Require Further Information, Analysis and/or Data collection to Reach Agreement

- Nature and extent of contamination throughout OU2 and boundaries of areas (horizontal and vertical) containing COCs at concentrations of concern
    - Definition of concentrations of concern (i.e. RGOs)
- Potential impact of OU1 on OU2 and/or the Tombigbee River via groundwater pathway
- What upper trophic levels are at risk from what contaminant
    - Exposure scenarios and parameter inputs to the updated risk evaluation
    - TRV updates
- HH risk estimates
    - What fish tissue results to utilize and whether data are adequate
    - Updated toxicity thresholds
- Identification of models for development of numeric clean up goals, and to evaluate remedial alternatives
- Numerical clean up goals for the COCs and associated remedial footprints (and depths if dredging is the alternative)
- Role of the flood plain in contributing methyl mercury to the basin and round pond, and potential need to evaluate remedies for the flood plain
    - Numeric goals for floodplain soils
- What remedial alternatives should be fully evaluated in the streamlined FS
    - Consider dredging along with capping alternatives

Summary of EPA's Proposed Strategy

- Complete updated risk assessments needed to complete ROD tables and generate cleanup criteria
  - EPA provides detailed comments on risk evaluations
  - Olin incorporates EPAs recommended endpoints, parameters, TRVs and address technical concerns with historical assessments (EPA will provide draft ROD Tables 6-2, 6-19 and 6-20)
    - Complete table summarizing ecological effects to each endpoint
      - Based on existing data using literature values
      - Based on supplemental data if required
  - Reach agreement on which model(s) will be used for mercury and other COCs to develop cleanup goals and evaluate alternatives
  - Use agreed upon model(s) (e.g, EPAs recommendation to use SERAFM coupled with BASS) to develop mercury cleanup goals, and to evaluate ESPP, active capping and dredging alternatives
- Based on updated risk assessments and selection of model(s) move forward in a collaborative manner to identify any and all supplemental data needs to resolve uncertainties related to issuing a ROD in 2010 beyond (or in place of) those discussed in Olin's ESPP, core/pore water or groundwater study plans.
  - Data gaps to update ecological or human health risk assessments?
  - Data gaps to support modeling to calculate clean up levels?
  - Data gaps to support evaluation of remedial alternatives?
- Olin produces addendum to the RI containing updated risk assessments and remedial goals
- Olin conducts detailed analysis of ESPP, active capping and dredging remedial alternatives against the CERCLA criteria
- Olin complete updated FS and publish evaluation of remedial alternatives
- EPA reviews and Olin Updates addendum and FS
- EPA completes ROD

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REVIEW OF OLIN OU-2 HISTORICAL DOCUMENTS FOR THE PURPOSES OF IDENTIFYING UNCERTAINTIES AND DATA GAPS

EPA conducted a review of historical documents submitted for Olin OU-2 for the purposes of identifying if there were any data gaps or supplemental tasks to be performed to allow for continued progress to be made at this site toward the identification of a remedy and the development of a Record of Decision. Documents reviewed include the 1995 Ecological Risk Assessment developed by Woodward–Clyde Consultants, the Human Health Risk Assessment submitted as part of the 1993 Remedial Investigation Report by Woodward-Clyde Consultants, the 2002 Remedial Goal Option Sampling Report developed by URS, and the 1996 Feasibility Study developed by Woodward-Clyde Consultants. The review also included an evaluation of the overall data set and its adequacy for characterizing nature and extent of contamination. These comments are intended to supplement comments already provided on these reports as well as more recent reports and work plans, and in no way supersede comments already provided.

1.0 ECOLOGICAL RISK ASSESSMENT (Dated May 1995)

EPA reviewed the 1995 Ecological Risk Assessment drafted by Woodward Clyde to ensure that the ecological problem formulation and risk protocols used were consistent with current practice and the current understanding of site conditions.

1.1 Data Representativeness and Usability

The ecological risk assessment was conducted based upon sediment and surface water collected in 1991, 1992, and 1994, and biological tissue (bullfrog, crayfish, mussel, mosquito fish, aquatic insect, terrestrial insect, raccoon, little blue heron) collected in 1994. Largemouth bass collected in 1991 were also utilized.

Spatial and temporal variability are inherent in environmental data, and data collection efforts generally focus on capturing nature and extent of contamination with sufficient sample size and spatial coverage to capture estimates of variability. Because the 1991 sediment samples were systematically place on a grid, an unbiased spatial coverage representative of the OU-2 Basin was attained. Biota sampling in 1994 was not done systematically, which may impact the exposure point concentrations used in the ecological risk assessment. For instance, mussels were collected in the southeast portion of the Basin, but not where sediment mercury locations were most elevated, meaning that EPCs for mussels may be underestimated than if samples had achieved better spatial coverage across low and high mercury areas. Mosquitofish and frog samples were collected around the entire northern edge of the basin and Round Pond, achieving a better range of spatial coverage than mussels. Other less sedentary biota (birds, raccoons, bass) by necessity must be collected wherever you encounter them, but due to their roaming nature they integrate exposure across lower and higher contaminated areas, so specifically seeking them in areas of high or low exposure is less important. Mercury concentrations in some biota, e.g. mosquitofish and crayfish, collected in OU-2 Basin exhibited relatively consistent Hg concentrations independent of collection location within the basin. Mercury concentrations in 14 mosquitofish samples collected in OU-2 Basin in 2001 ranged between 0.41 and 0.51 mg/kg wet wt. (with one sample at 0.19 mg/kg wet wt.), compared to 0.04 to 0.14 mg/kg wet wt. in the Tombigbee Reference Area. Mercury in OU-2 Basin crayfish samples ranged between 0.13 and 0.20 mg/kg wet wt., compared to 0.04 mg/kg wet wt. in the Reference Area. This suggests that although total Hg concentrations may vary widely across the Basin, relative bioavailability of mercury may be about the same between higher and lower areas of Hg contamination.

Temporal variability in sediment is likely a longer term process in OU-2 that is influenced by erosional, depositional, bioturbation and sediment resuspension processes. However, temporal variability in surface water is potentially a more important issue due to the complex chemistry of mercury, and all of the various factors that influence mercury methylation. The reasons for the temporal variability of mercury in surface water observed in the historical represent an uncertainty. Higher concentrations of mercury were noted in surface water during June 1994 sampling than were noted in August 1991 sampling. The ERA attributed this to the fact that the 1994 samples were collected during a flood period and stated that the higher concentrations were the result of increased total suspended solids in the 1994 samples. However, the report did not consider the possibility that the elevated Hg in 1994 surface water could be the result of increased methylation due to flooding of wetland sediments. Because methylmercury was not measured in these earlier samples, the reason for the higher mercury concentrations in 1994 surface water samples remains an uncertainty, and no data site specific data is available to assess temporal variations in methylmercury production associated with flood events or seasonal changes in conditions. EPA's current proposal is to address this uncertainty with methylmercury screening model.

Ecological Problem Formulation

A summary of the exposure pathways, assessment endpoints, and measurement endpoints evaluated in the 1995 ERA are presented in Table 1. The ecological problem formulation was reviewed for consistency with the understanding of OU-2 site conditions and the current state of the practice for evaluating ecological risk.

Assessment Endpoints

The 1995 ERA identified 9 Assessment Endpoints. EPA concurs that those nine assessment endpoints are still appropriate and relevant for assessing ecological risk within OU-2. However, because the assessment endpoints for omnivorous birds and insectivorous birds are evaluating primarily terrestrial exposures from the floodplain soils and terrestrial plants and insects, EPA recommends adding two additional assessment endpoints: omnivorous birds with an aquatic diet, and insectivorous birds with an aquatic diet. These additional assessment endpoints are warranted since the OU-2 Basin has higher concentrations of mercury than the terrestrial floodplain areas. However, since the highest concentrations of DDTr occur in the floodplain, it is prudent to retain the existing omnivorous bird and insectivorous bird endpoints for evaluation of risk from these terrestrial areas as well.

Measurement Endpoints

The 1995 ERA identified a range of measurement endpoints to address the above assessment endpoints. These measurement endpoints are summarized in Table 1.

Based on evaluation of the three measurement endpoints for evaluation of risk to benthic invertebrate community, the ERA concluded that there was risk to "general aquatic organisms" from Hg in Round Pond and OU-2 Basin; from DDT in Cypress Swamp, Round Pond and OU-2 Basin; and risk to crayfish from DDT in Round Pond and OU-2 Basin. However, there are several uncertainties with these measurement endpoints and the way they were evaluated.

1. The first two of these measurement endpoints involve comparing surface water concentrations of COPCs to published toxicity reference values or other water quality criteria. The 1995 ERA listed "survival of aquatic organisms" and "development, growth, and reproduction of aquatic organisms" as separate measurement endpoints. However the same water quality criteria and TRVs were used to evaluate "survival" as were used to evaluate "development, growth, and reproduction", so they are really the same endpoint. Therefore, they were combined into single endpoints in Table 1.

2. Surface water samples were collected from two discrete depths (but not at the sediment/water interface) in 1991/1992, and from near the surface in 1994. The depths at which surface water were collected do not represent the exposure points for benthic organisms, which dwell at the sediment water interface or in the oxic layers of surface sediment. Sediment pore water or water collected at the sediment/water interface, or sediment concentrations themselves would be more appropriate for assessing exposure to benthic organisms. The surface water samples used for comparison are appropriate for evaluating risk to pelagic (water column dwelling) organisms. It is recommended that the updated risk assessment evaluate risk identify the existing evaluation as a measurement endpoint for aquatic invertebrates to distinguish from benthic organisms, and add a measurement endpoint in which sediment concentrations are compared to sediment benchmarks for the benthic invertebrate evaluation. Existing data is available to screen risk to surface water and sediment organisms for the COPCs identified in the RI report. This task could be completed with existing data and updated toxicity benchmarks and summarized in the risk assessment addendum.

3. The mercury TRV for swamp crayfish (5.6 μg/L) is based on an LC50 divided by an uncertainty factor [UF] of 10. Application of an uncertainty factor of 10 is generally performed to estimate an **acute** LOAEL from an LC50. This is appropriate for evaluating survival of crayfish. However, evaluation of chronic effects of impacts to growth, development, and reproduction cannot be answered by use of an acute LOAEL. Lacking specific toxicity data to derive a chronic LOAEL, one can be estimated by applying an uncertainty factor of 10 to the acute

LOAEL (i.e. an uncertainty factor of 100 to the LC50). Therefore the chronic LOAEL TRV for swamp crayfish would be 0.56 µg/L. Use of this TRV would result in a finding of potential risk to white swamp crayfish from mercury in OU-2 Basin. It is recommended that the updated ERA look at literature that has been published since 1995 to determine if newer toxicity information is available to assess risk to benthic invertebrates from Hg in sediment and water to reduce the uncertainty associated with estimating chronic LOAELs from LC50 data.

4. Some lines of evidence were apparently discounted. High incidents of oligochaete chaetal aberrations were noted at some sampling locations, and it is noted in the ERA that such aberrations may be biomarker of heavy metal toxicity. Also, organism density and community structure differences between OU-2 and reference site were noted. However, multivariate statistical analyses conducted as part of the RI found no statistical correlation between sediment chemistry and the observed results. The ERA noted that density and community structure were impacted by hypolimnetic conditions in the deep hole. The revised ERA could re-analyze the original benthic community data omitting the samples collected from the deep hole if it is deemed informative to have that information. However, if it is determined that risk to upper trophic levels is what is truly driving risk to ecological receptors, the uncertainty associated with interpretation of the benthic community data is a minor one.

5. No attempt was made to evaluate direct toxicity of sediments to benthic organisms such as conducting aquatic toxicity tests that are able to evaluate whether the combination of chemicals present in OU-2 sediments is acutely or chronically toxic to benthos. In the absence of such data it is important to use the most conservative toxicity values derived from the literature to avoid underestimating potential toxicity.

Based on the evaluation of five measurement endpoints for the protection of fish communities, the ERA concluded that survival, growth, development, and reproduction of mosquitofish were likely impacted by DDTr in Round Pond and Cypress Swamp; survival, growth, development and reproduction of bass were likely impacted by mercury and DDTr in the Basin and Round Pond; the physical condition of fish in OU-2 was not reduced compared to regional conditions; limited forage base may have an indirect effect on growth of fish in OU-2; and survival and growth of fish was unlikely to be reduced due to tissue burdens. The primary uncertainties associated with the 1995 evaluation of risk to fish are as follows:

1. The mercury and DDTr TRVs for mosquitofish (3.7 µg/L and 0.8 µg/L, respectively), and the DDTr TRV for bass (0.08 µg/L) are based on LC50 values divided by an uncertainty factor of 10. As previously mentioned, application of an uncertainty factor of 10 is generally performed to estimate an **acute** LOAEL from an LC50, which is appropriate to address survival endpoints, but not development, growth, or reproduction endpoints. Applying a further uncertainty

factor of 10 to account for the acute to chronic effects conversion would result in a finding of potential risk to mosquitofish from mercury in OU-2 Basin, and increase the magnitude of risk to mosquitofish and bass from DDTr. It is recommended that the updated ERA look at literature that has been published since 1995 to determine if newer toxicity information is available to assess risk to benthic invertebrates from Hg in sediment and water to reduce the uncertainty associated with estimating chronic LOAELs from LC50 data.

2. The two fish species analyzed (mosquitofish and bass) are primarily water column feeders. Bottom feeders such as catfish would potentially have greater exposure to contaminated sediments (especially DDTr and HCB), and therefore potentially higher risk than water column feeders. However this was not necessarily reflected in 1991 channel catfish data, which had an average whole body mercury concentration of 0.44 mg/kg wet wt., compared to 0.79 mg/kg wet wt. mercury in whole body bass samples. Based on existing data, mosquitofish and largemouth bass are appropriate surrogates for forage fish and game fish, respectively.

For each of the food web endpoints, the 1995 ERA evaluated High End Risk Level (HERL) and Moderate End Risk Level (MERL) risk endpoints. HERL scenarios used more conservative assumptions, but no consistent protocol was used to differentiate HERL from MERL scenarios (e.g. some endpoints varied ingestion rates between MERL and HERL, some did not; some varied Area Use Factors, some did not). MERL scenarios used mid-point or mean exposure parameters. The HERL scenario is a good method for placing an upper bound on exposure, but for a site where nature and extent are well defined, a scenario that uses conservative estimators of mean site conditions (e.g. 95%UCL on the mean) is appropriate for risk decision making purposes. If nature and extent are in question, then a more conservative scenario such as the HERL is appropriate for making risk-based decisions. The uncertainties associated with the food web risk calculations are divided into five main categories: Surrogate Endpoint Selection, Exposure Parameters, and Risk Calculations, which are each discussed below.

Surrogate Endpoint Selection

Raccoon and river otter were chosen in the ERA to represent omnivorous mammals and piscivorous mammals, respectively. Both of these mammals are expected to occur in the vicinity of OU-2 as year-round residents, utilize both floodplain and open water areas for foraging, and include the most exposed receptors (fish and aquatic invertebrates) as a portion of their diets. As such, these are appropriate surrogate receptors for omnivorous and piscivorous mammals.

Red-winged blackbird was chosen as the surrogate receptor for omnivorous birds. Red-winged blackbird, as modeled in the 1995 ERA, is an appropriate receptor for assessing risk to omnivorous birds from chemical constituents in the OU-2 floodplain because of its largely terrestrial diet, but it is not an appropriate avian omnivore for OU-2 Basin, where an aquatic diet is required. Examples of appropriate omnivorous avian receptors for OU-2 Basin are Mallard (*Anas platyrhynchos*), American Coot (*Fulica Americana*), or Wood

Duck (*Aix sponsa*), which are all birds that feed on a variety of plant material and aquatic invertebrates, are listed in the ERA as resident at or in the vicinity of OU-2, and would be more exposed to aquatic contaminants than red-winged blackbird. EPA will submit recommendations for an omnivorous avian receptor which utilizes an aquatic diet for the project team to review.

Prothonotary warbler was chosen as the surrogate receptor for insectivorous birds. As with red-winged blackbird, prothonotary warbler is an appropriate receptor for assessing risk to insectivorous birds from chemical constituents in the floodplain because it feeds primarily upon terrestrial invertebrates, but not for assessing risk in OU-2 Basin, where an aquatic invertebrate diet is appropriate. EPA will submit recommendations for an omnivorous avian receptor which utilizes and aquatic diet for the project team to review.

Two surrogates were chosen to represent piscivorous birds: snowy egret and belted kingfisher. Belted kingfisher is an appropriate receptor due to its largely piscivorous diet and potential to be a year round resident in OU-2. Kingfishers feed on a variety of small forage fish, such as *Gambusia*. Snowy egrets utilize the same size class forage fish as kingfishers, resulting in feeding niche overlap with belted kingfisher. It may be more appropriate to consider great blue heron in lieu of snowy egret, because great blue heron is capable of consuming larger fish species, thereby providing less overlap in its feeding niche with belted kingfisher. Great blue herons occur at OU-2, can feed in deeper water than snowy egrets, and are known to exploit feeding territories as small as 1.5 acres in size (EPA Wildlife Exposure Factors Handbook, 1993).

The surrogate receptor for carnivorous reptiles was the American alligator. Alligators are known to occur in OU-2, and eat a variety of fish, birds, and mammals. Reptiles as an assessment endpoint are difficult to evaluate in risk assessments due to the scarcity of toxicity data. The Hg TRV used to evaluate alligators in the 1995 was based on a single study that was the result of an accidental mercury spill, and found no effect to alligators at a derived dose of 3.7 mg/kg-d. It is recommended to retain alligator as an OU-2 receptor and to conduct an updated literature review to determine if more recent toxicity information is available to assess risk from mercury, DDTr, and HCB to reptiles.

Food Web Exposure Parameters

As mentioned previously, the risk assessment calculated risk based on both HERL and MERL scenarios, but there was no consistent approach in how HERL scenarios differed from the MERL scenarios. For instance, raccoon, river otter, and belted kingfisher models each varied ingestion rate, body weight, and proportion of food materials in diet between HERL and MERL scenarios. Red-winged blackbird and prothonotary warbler models varied only the proportion of food materials in diet, while the snowy egret model varied proportion food material and site use factor (SUF), also referred to as area use factor (AUF). Because of the adequate spatial coverage of sediment data in OU-2 Basin (when all historical data is considered), the availability of different types of biotic tissue data spanning multiple trophic levels, and the relatively high levels of COCs present in OU-2, it is recommended that additional efforts to characterize ecological risk focus on a scenario that uses 95%UCLs for exposure parameter inputs whenever possible. Olin, EPA Region 4 and other stakeholders will need to agree upon the exposure parameter inputs for each receptor prior to updating the risk calculations. EPA will submit recommendations for updated exposure parameters for the project team to review. Toxicity reference values have changed since the time the risk assessment was produced. Recommended toxicity reference values will be provided with the recommended exposure assumptions. Any potential updates to information or corrections can be performed in the risk assessment addendum. Comments on some specific exposure assumptions used in the 1995 ERA are presented below.

Diets for most omnivorous receptors vary, often on a geographic and/or seasonal basis. Based upon the potential for bioaccumulation of the primary OU-2 COCs, omnivorous diets in which animal matter is emphasized over plant matter are preferred. The two omnivores evaluated in the 1995 ERA, raccoon and red-winged blackbird, varied the amount of invertebrate material ingested between the HERL and MERL scenarios. For instance, the modeled raccoon diet consisted of 35% plant material in the MERL scenario, and 9.1% plant material in the HERL scenario. Since the raccoon and red-winged blackbird are meant to be a surrogates for all omnivorous birds and omnivorous mammals, respectively, the diets that utilize a higher percentage invertebrate material are considered more protective of all omnivorous receptors. Dietary proportions of plant matter versus invertebrate material for omnivorous receptors will be part of the exposure parameters presented by EPA and will need to be agreed upon prior to update of the risk assessment.

Site Use Factor is one of the most sensitive parameters in food web equations because it has a linear 1:1 relationship with dose. The site use factors for two receptors, belted kingfisher and snowy egret, were potentially underestimated in the 1995 ERA. The 1995 ERA states the following about the belted kingfisher SUF: "According to Cornwell (1963), the typical foraging area of the belted kingfisher is about 8,042 acres. Dividing this area into the total area of OU-2 (227 acres) yields an AUF of 2.8 percent." However, kingfisher territories are more commonly expressed in units of "kilometers of shoreline", with the EPA (1993) stating the following: "The breeding territories (length of waterline protected) can be more than twice as long as the fall and winter feeding territories, and stream territories tend to be longer than those on lakes (Davis, 1982; Salyer and Lagler, 1946). Foraging territory size is inversely related to prey abundance (Davis, 1982)." The mean territory size from the studies reported in EPA, 1993 is 1.43 km of shoreline. OU-2 Basin contains over 1.8 km of shoreline, suggesting that a SUF of 1 is warranted for belted kingfisher. The 1995 ERA assumed a home range of 12,424 acres for showy egret, resulting in a site use factor of 1.8%. As discussed above, great blue heron is potentially a more appropriate piscivorous bird receptor than snowy egret. Both snowy egrets and great blue herons are communal nesting birds that can disperse great distances from rookeries to feeding areas. However both will remain in small areas to forage as long as adequate food supply exists. Bayer (1978) found that great blue herons' feeding territories ranged from 1.5 acres to 21 acres depending upon season. This information supports a site use factor of 1 for OU-2 Basin, even when foraging is limited to those areas with water depths less than 0.5 meters. Any proposed changes to Site Use Factors will be part of the proposed revised exposure parameters.

Risk Calculations

The 1995 ERA risk calculations contained one significant error. Ingestion rates for raccoon, red-winged blackbird, prothonotary warbler, and belted kingfisher were calculated based upon body weights using standard allometric equations developed by Nagy and provided in the EPA Wildlife Exposure Factors Handbook, 1993. These equations calculate amount of food material ingested per day on a dry weight basis. However, the 1995 ERA risk calculations were performed on a wet weight basis. Calculated ingestion rates were not converted to wet weight before use in the 1995 ERA. Wet weight ingestion typically ranges between two and four times higher than dry weight ingestion, depending upon moisture content of food items ($Wet\_Weight\_Ingestion = \frac{Dry\_Weight\_Ingestion}{1 - proportion\_moisture}$). The result is that risk was under-reported for raccoon, red-winged blackbird, prothonotary warbler, and belted kingfisher. The 1995 ERA states that an ingestion rate of 0.356 kg/d was used for river otter, based on allometric relationships developed by Nagy. However, the risk calculations appear to use an ingestion rate of 1.11 kg/d. The source of this value is unclear, but it may represent a wet weight converted ingestion rate. The ingestion rate for snowy egret was based on allometric equations for wading birds developed by Kushlan (1978), which yields a wet weight ingestion rate, so risk calculations for snowy egret were conducted appropriately in the 1995 ERA.

Conclusions of the Ecological Risk Assessment Review

EPA recommends that the ecological risk assessment be updated to correct the errors in the original risk assessment and to characterize risk under current conditions in OU-2 Basin and the floodplain. EPA will submit recommendations for additional surrogate receptors and updated exposure assumptions for the project team to review. EPA will submit recommendations for the toxicity reference values and exposure assumptions.

Table 1. 1995 Ecological Problem Formulation Summary: Assessment Endpoints, Measurement Endpoints, Ecological Exposure Pathways of Concern (items in red represent suggested changes/additions)						
Exposure Medium	**Sensitive Environment Flag (Y or N)**	**Receptor**	**Endangered / Threatened Species Flag (Y or N)**	**Exposures Routes**	**Assessment Endpoints**	**Measurement Endpoints**
Surface Water		Benthic Invertebrates (change to "Aquatic Invertebrates")	N	Direct contact with surface water	Protection of benthic macroinvertebrate community (change to "Protection of aquatic macroinvertebrate community")	Are survival, development, growth, and reproduction among sensitive aquatic organisms potentially reduced as a result of exposures to surface-water concentrations of mercury and DDTr (as evaluated by comparisons to federal AWQCs)?
Surface Sediment		Benthic Invertebrates	N	Direct contact with surface sediment	Protection of benthic macroinvertebrate community	Are survival, development, growth, and reproduction among sensitive benthic organisms potentially reduced as a result of exposures to surface sediment concentrations of mercury, HCB, and DDTr (as evaluated by comparisons to sediment toxicity benchmarks)?
Surface Water		Benthic Invertebrates, as represented by White Crayfish	N	Direct contact with surface water	Protection of benthic macroinvertebrate community	Are survival, development, growth, and reproduction of individual white swamp crayfish potentially reduced as a result of exposures to surface-water concentrations of mercury and/or DDTr (as evaluated by comparisons to reported TRVs)?
Sediment/Surface Water		Benthic invertebrates	N	Direct contact with sediment/ surface water	Protection of benthic macroinvertebrate community	Relationship between patterns of community composition and relative densities of benthic macroinvertebrates in the OU-2 Basin and measured bulk-sediment concentrations of COPCs. Specifically, for example, are there tendencies for reduced diversity (taxonomic richness), increased relative frequency of pollutant-

Table 1. 1995 Ecological Problem Formulation Summary: Assessment Endpoints, Measurement Endpoints, Ecological Exposure Pathways of Concern (items in red represent suggested changes/additions)						
Exposure Medium	**Sensitive Environment Flag (Y or N)**	**Receptor**	**Endangered / Threatened Species Flag (Y or N)**	**Exposures Routes**	**Assessment Endpoints**	**Measurement Endpoints**
						tolerant forms, and reduced densities in areas with elevated bulk-sediment concentrations of COPCs?
Surface Water		Mosquitofish	N	Direct contact with surface water	Protection of fish community	Are survival, development, growth, and/or reproduction of mosquitofish potentially impaired as a result of direct exposures to mercury and/or DDTr (as evaluated by comparison of surface-water concentrations to appropriate TRVs)?
Surface Water		Large Mouth Bass	N	Direct contact with surface water	Protection of fish community	Are survival, development, growth, and/or reproduction of largemouth bass potentially impaired as a result of direct exposures to mercury and/or DDTr (as evaluated by comparison of surface-water concentrations to appropriate TRVs)?
Sediment, surface water, prey items		Multiple fish species	N	Direct uptake, ingestion of food, sediment, and water	Protection of fish community	Is the general physical condition of individual fish impaired as a result of direct and/or indirect exposures to COPCs (as evaluated by comparing the index K_T for OU-2 individuals to regional or reference area values)?
Surface Water		Aquatic organisms, crayfish, and mosquitofish	N	Indirect measurement based on potential effects to prey base	Protection of fish community	Are the growth rates of individual fish potentially reduced as an indirect result of the toxicity of COPCs to prey (as evaluated by comparison of surface-water concentrations to estimated or reported adverse effects levels for aquatic organisms in general,

Table 1. 1995 Ecological Problem Formulation Summary: Assessment Endpoints, Measurement Endpoints, Ecological Exposure Pathways of Concern (items in red represent suggested changes/additions)						
Exposure Medium	**Sensitive Environment Flag (Y or N)**	**Receptor**	**Endangered / Threatened Species Flag (Y or N)**	**Exposures Routes**	**Assessment Endpoints**	**Measurement Endpoints**
						crayfish, and mosquitofish)?
Sediment/surface water, prey items		Channel catfish, large mouth bass, mosquitofish	N	Direct uptake, ingestion of food, sediment, and water	Protection of fish community	Are the survival, growth, and/or reproduction of channel catfish, mosquitofish, and largemouth bass potentially reduced as a result of tissue burdens of COPCs (as evaluated by comparing measured whole-body concentrations with levels reportedly associated with adverse effects)?
Floodplain soil		Floodplain plants	N	Root uptake from soils	Protection of biological integrity of terrestrial plant communities	Vegetation survey and vegetation stress survey of floodplain plants
Sediment, surface water, biotic tissue		American Alligator	N (was T&E listed at the time of the 1995 risk assessment, but has since been delisted)	Dietary ingestion	Protection of Predatory Reptiles and Amphibians from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of American alligators potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Soil, surface water, biotic tissue (terrestrial)		Red-winged blackbird as surrogate for terrestrial avian omnivores	N	Dietary ingestion	Protection of terrestrial omnivorous birds from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of red-winged blackbirds potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Sediment, surface water, biotic tissue (aquatic)		??? as surrogate for aquatic avian	N	Dietary Ingestion	Protection of aquatic omnivorous birds from direct toxicity	Are development, growth, and/or reproduction of ??? potentially impaired as a result of dietary

Table 1. 1995 Ecological Problem Formulation Summary: Assessment Endpoints, Measurement Endpoints, Ecological Exposure Pathways of Concern (items in red represent suggested changes/additions)						
Exposure Medium	**Sensitive Environment Flag (Y or N)**	**Receptor**	**Endangered / Threatened Species Flag (Y or N)**	**Exposures Routes**	**Assessment Endpoints**	**Measurement Endpoints**
		omnivores			and indirect effects due to exposure to site-related COPCs	exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Soil, surface water, biotic tissue (terrestrial)		Prothonotary Warbler as surrogate for terrestrial avian insectivore	N	Dietary ingestion	Protection of terrestrial insectivorous birds from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of prothonotary warblers potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Sediment, surface water, biotic tissue (aquatic)		??? as surrogate for aquatic avian insectivore	N	Dietary Ingestion	Protection of aquatic insectivorous birds from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of ???? potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Sediment, surface water, biotic tissue		Belted Kingfisher, Snowy Egret (great blue heron in lieu of snowy egret?)	N	Dietary ingestion	Protection of piscivorous birds from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of belted kingfishers or snowy egrets potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Sediment, surface water, biotic tissue		Raccoon	N	Dietary ingestion	Protection of omnivorous mammals from direct toxicity and indirect effects due to exposure to site-related COPCs	Are development, growth, and/or reproduction of raccoons potentially impaired as a result of dietary exposures to mercury, HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?
Sediment, surface water, biotic tissue		River Otter	N	Dietary ingestion	Protection of piscivorous mammals from direct toxicity	Are development, growth, and/or reproduction of river otters potentially impaired as a result of

Table 1. 1995 Ecological Problem Formulation Summary: Assessment Endpoints, Measurement Endpoints, Ecological Exposure Pathways of Concern (items in red represent suggested changes/additions)

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered / Threatened Species Flag (Y or N)	Exposures Routes	Assessment Endpoints	Measurement Endpoints
					and indirect effects due to exposure to site-related COPCs	dietary exposures to mercury. HCB, and/or DDTr (as evaluated by comparing estimated doses to TRVs)?

2.0 HUMAN HEALTH RISK ASSESSMENT (RI Report dated July 1993)

Primary deficiencies of the Olin 1993 RI/FS OU-2 Human Health Risk Assessment (HHRA) relate to the vintage of the risk assessment and updates to methodology and data since the analysis was completed.

The risk driver in the 1993 RI/FS OU-2 HHRA was exposure of trespassers and off-site residents to mercury in consumed fish. Major data gaps for the 1993 OU-2 HHRA should focus on the dose response assumptions for methylmercury (updated RfDo), calculation of exposure point concentrations (EPCs) using the updated USEPA methodology, and additional fish samples collected since 1991. A minor risk driver for the 1993 RI/FS OU-2 HHRA was organic chemicals in consumed fish (hexachlorobenzene, DDT, DDD, DDE). Data gaps for the organic chemicals in fish are additional fish samples and updated EPC calculation methods.

Methylmercury Oral Reference Dose (RfDo)

At the time the RI/FS was published in 1993, the RfDo for methylmercury was 3E-4 mg/kg-day. In the late 1990's the USEPA updated the RfDo for methylmercury to 1E-4 mg/kg-day; still the current value (see USEPA IRIS record for methylmercury, http://www.epa.gov/ncea/iris/subst/0073.htm). Both the RME adult and adolescent receptors each had an HI for exposure to mercury in fish of 0.367 in the 1993 RI/FS. This HI was more than an order of magnitude greater than exposure to chemicals in domestic well water (HI = 0.0196). If all other parameters and assumptions remain unchanged, but the methylmercury RfDo is lowered from 3E-4 mg/kg-day to 1E-4 mg/kg-day, then the HI for consumption of fish contaminated with mercury for the adult and adolescent receptors increases to 1.1; clearly above levels of concern.

Fish Sampling and Analysis; Mercury

The results of the 1993 RI/FS OU HHRA for consumption of fish were based on an exposure point concentration (EPC) calculated from the analysis of total mercury in 10 largemouth bass and 10 channel catfish fillets (EPC = 1.45 mg/kg). However, additional fish data is available from samples collected and analyzed by Olin (or its contractors) and/or the Alabama Department of Environmental Management (ADEM) in 1986, 1993, 2001, 2002, and 2003). Olin has analyzed mercury in both whole fish, as well as fillets. The results from ADEM appear to contain only fillet data. Only data for edible fish fillets (bass, sunfish, mullet, etc.) were evaluated as part of the data gap analysis.

Box plots of the different data sets for fish from the Olin Basin and other locations are shown in Figure 1. These plots indicate that the concentration in mercury in fish fillets collected from the Olin Basin is higher than that in fish collected elsewhere in Alabama. The Tombigbee2 location is at the confluence of the Tombigbee River and the outfall from the Olin Basin to the river. The 2002 ADEM Olin Basin results appear to be significantly higher than any of the other Olin Basin sample results, though the resons for this are not clear.

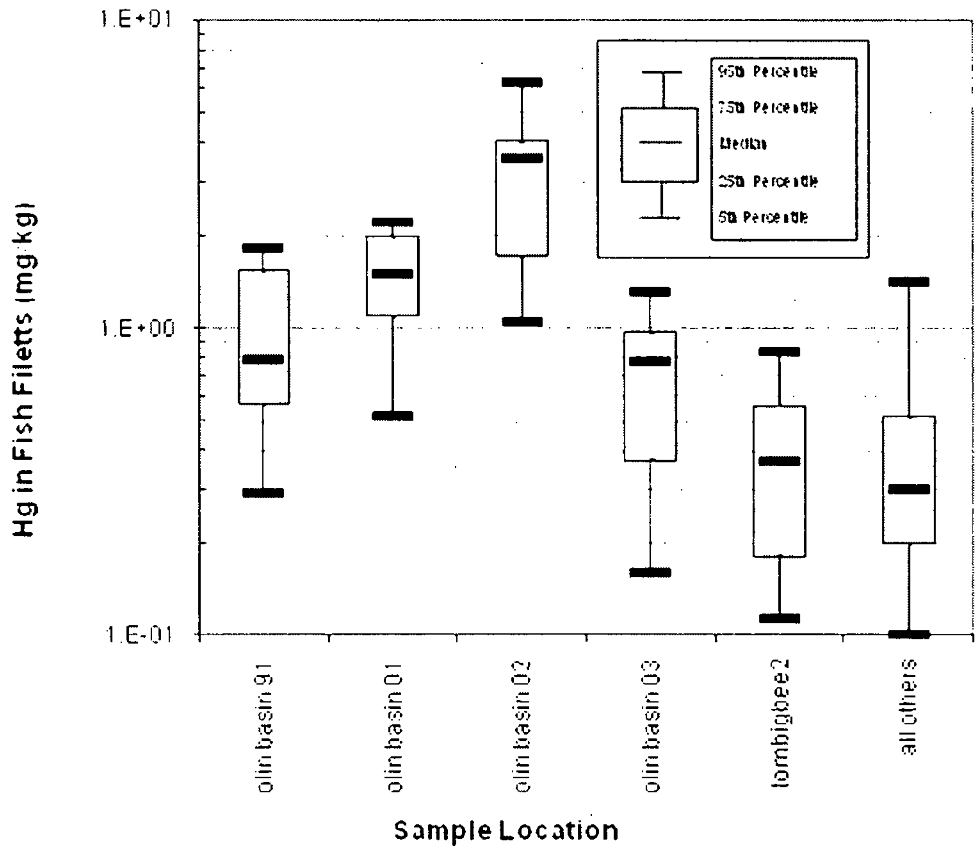

Figure 1. Mercury in Edible Fish Fillets.

A comparison of the ADEM 2002 results were compared to the aggregate 1986, 1991, 2001, and 2003 Olin results using the Mann-Whitney (M-W) Rank Sum Test. These test results ($p<0.001$) indicate that the difference between the ADEM and Olin results is significant.

Further analysis was conducted by calculating EPCs using all the data and various subsets of all the available data. The EPC calculated (based upon the H statistic 95% UCL on the mean) for the 1993 RI/FS for largemouth bass and channel catfish fillets was 1.450 mg/kg. However, based upon current published USEPA methodology (USEPA ProUCL website, http://www.epa.gov/esd/tsc/software.htm), the EPC calculated using only the 1991 bass and catfish fillet data in the RI/FS would be 1.324 mg/kg (based upon the 95% UCL on the mean using the gamma distribution on the underlying data). If all of the fish fillet data is used (1986, 1991, 2001, 2002, 2003), then the calculated would be EPC 1.634 mg/kg (95% UCL, gamma). If the ADEM 2002 fish fillet data is excluded (only Olin data from 1986, 1991, 2001, 2003 is used) then the EPC drops to 1.025 mg/kg (95% UCL, gamma).

The cause of the differences between the ADEM and Olin data are not certain. Some possible explanations include changes in environmental/meteorological conditions or differences between the ADEM and Olin fish fillet collection, preparation or analytical techniques. There do not appear to be any significant differences in the Olin Basin total mercury surface sediment concentrations over the time the fish samples were collected, however, it is unknown whether other conditions that facilitate methylation may have changed over this period of time.

Changes in estimates of the mercury fish fillet EPC directly affect changes in the estimated Hazard Index. If all of the currently available data is used to calculate fish fillet mercury EPC (1.634 mg/kg) then the EPC used in the 1993 RI/FS (EPC = 1.450 mg/kg) underestimates the HI by about 10%. However, if the 2002 ADEM fish fillet mercury results (EPC = 1.025 mg/kg) are excluded (per the box plots and M-W test results), then the RI/FS EPC (EPC = 1.450 mg/kg) over estimates the HI by about 40%. If however, the EPC on the data set used for the 1993 RI/FS is just recalculated (EPC = 1.324 mg/kg), then the RI/FS overestimates the HI by about 10%.

However, the differences in estimated hazards due to different fish data sets or different EPC calculation methods is still small relative to differences in hazard resulting from the use of the current RfDo (HI = 1.1) for methylmercury (vice the RfDo used in the 1993 Olin RI/FS, HI = 0.367).

All of fish fillet data is based upon analysis for total mercury. However, the vast majority of mercury in fish flesh (95-99%) is assumed to be methylmercury (see for example the USEPA 1997 Mercury Study Report to Congress). Based upon the above discussion, any differences in the analytical results based upon total mercury and an assumption that it is all methylmercury is inconsequential.

Fish Sampling and Analysis; Organics

All of the EPCs for DDT, DDD, DDE, and hexachlorobenzene (HcB) in 1993 RI/FS for fish fillets were calculated using the H statistic assuming a lognormal distribution. All non-detect (ND) values were treated assuming the ND value was ½ the limit of detection (LOD). Current methodologies for calculating EPCs, using sophisticated methods for treating ND values, were used to recalculate the EPCs in fish fillets for these four chemicals. In addition, data for these four chemicals in fish fillet from ADEM 2002 sampling were also included. The original and revised fish fillet EPCs along with the percent change are provided in Table 2. As this table shows, incorporation of the more recent data and up-to-date EPC calculation methods results in lower estimates of the EPCs for these chemicals in fish fillets.

Table 2. EPCs for Organic Chemicals in Edible Fish Fillets (mg/kg).

Chemical	RI/FS EPC	Updated EPC	Percent Change
DDT	0.524	0.157	-70
DDD	2.10	1.507	-28
DDE	3.45	2.644	-23
HcB	0.377	0.174	-54

All four chemicals were evaluated as having carcinogenic risk in the RI/FS. Based upon the updated EPCs, the overall carcinogenic risk to adult trespassers would be reduced from 8E-5 to 5E-5.

Review of the two data sets (Olin 1991 and ADEM 2002) shows that the LOD for the 2002 ADEM data are significantly lower for DDT, DDD, and DDE than the LOD for these chemicals in the 1992 Olin data. This was investigated further by application of the M-W Rank Sum Test to the two data sets for each of these three chemicals. In all case the results for the 2002 ADEM fish fillets were significantly lower than the concentrations in fish fillets collected by Olin in 1991. This may be due to decreased concentrations of these three chemicals due to decomposition in the environment, as well as reduced or no releases to the environment. Both of these suppositions are supported by the average Olin Basin surface sediment concentrations for 1991, 2004 and 2005 presented in Table 3. A clear reduction in concentration with time is evident in this data.

Table 3. DDT, DDD, and DDE Average Surface (0-0.5 ft) Sediment Concentrations (mg/kg).

Year	4,4'-DDD	4,4'-DDE	4,4'-DDT
1991	0.548	0.537	0.387
2004	0.0119	0.0334	0.0033
2005	0.0145	0.0594	0.0102

The significant differences in the edible fish fillet concentrations for DDT, DDD, and DDE for the 1992 and 2002 data sets and the reduction in Olin Basin surface sediment concentrations for these chemicals from 1991 to 2004/2005 suggests that additional sediment and fish data could show even further reductions in the concentrations of these chemicals, resulting in even lower risk estimates for DDT, DDD, and DDE for the adult and adolescent trespassers. In the absence of new additional data, it is questionable how representative the available data is of the current site conditions.

Comparison of the HCB fish fillet results for 1991, 2001, and 2002 using the M-W Rank Sum Test shows that the 1991 results are significantly higher than the 2001 or 2002 results, and there is no significant difference between the mercury concentration in fish fillets between 2001 and 2002. Due to the limited number of recent data, this downward trend may need confirmation through additional sampling, so that data representative of current site conditions can be evaluated.

Conclusions of the Human Health Risk Assessment Review

The OU-2 HHRA for fish consumption for mercury should be re-evaluated based upon current toxicology and revised estimates of mercury EPCs in fish fillets. Thought should be given to the 2002 ADEM results and their inclusion or exclusion in the re-evaluation of risk.

The OU-2 HHRA for fish consumption for DDT, DDD, DDE, and HcB should be re-evaluated based upon current methods for calculating EPCs. Consideration should also be given to collection of additional fish and sediment data to confirm reductions in concentration over time and to have data representative of current site conditions. From the existing data, it appears that the lower RfDo will result in HQs>1 regardless of which subset of data or method for calculating the EPC is used. This should be confirmed through re-analysis and a decision made as to whether supplemental data is required, or if it is sufficient to simply confirm that remedial action goals for ecological risk will be adequate to address unacceptable human exposure.

3.0 REMEDIAL GOAL OPTION SUPPORT SAMPLING REPORT (Dated April 2002)

One of the key uncertainties related to OU-2 is what concentrations of Hg, DDTr, and HCB will be protective of human and ecological receptors, and prevent unacceptable off-site transport of COCs, and what is an acceptable timeframe for achieving this goal. As part of the effort to review all historical documents, EPA has taken a fresh look at the 2002 Remedial Goal Option (RGO) Support Sampling Report and offers the following comments and observations. This report focuses on sediment and biota data collected in 2001 aimed at reducing uncertainties regarding sediment concentrations and food chain modeling, and how the results compare with earlier studies.

- The RGO report indicates that the sample collection occurred during the week of 4 September, 2001, a time of unseasonably high-water levels resulting in flood or near-flood conditions in the Basin and Round Pond, and that largemouth bass collection had to be collected some three weeks later on 1 October, 2001. This raises the question as to whether the bass that were collected were long term residents of the Basin, or instead came into the Basin during the flooding event. If the fish were not long term residents, then the concentration of mercury in their tissue may be lower than would be achieved at equilibrium, and help explain why bass collected in the following year by ADEM were higher.
- The RGO report concludes that due to the poor relationships and lack of correlation between bulk-sediment mercury concentrations and tissue concentrations, BSAFs cannot be reliably calculated and used to determine concentrations in sediment that are expected to result in decreased tissue levels and corresponding risk to upper trophic levels or human health. EPA agrees in general with this statement, however disagrees with the conclusion that a reduction of sediment mercury will not result in a reduction in biota tissues. The

issue at stake is a determination of the concentration below which methylation processes will be impeded, and in all likelihood, based on other mercury contaminated sites across the country this may require total mercury levels below 1 ppm.

- EPA agrees with the RGO findings that due to spatial variability of Hg, decisions should be made on a regional basis, not a sample-by-sample basis, and spatial weighting may be an appropriate tool.
- BSAF calculations were attempted, using lipid and TOC normalization for HCB and DDTr, and without normalization for Hg.
- It is unclear why dry-weight sediment and wet-weight tissue would be used, and not dry-dry or wet-wet values. The text in Sec 5.2.2 indicates BSAFs were calculated by dividing dry-weight sediment by wet-weight tissue; however, the tables correctly put tissue over sediment. However by using wet-weight tissue, BSAFs would be underestimated (the numerator would be smaller than if dry-weight conversions were done).

The RGO report attempts to calculate BSAFs for total mercury, and concludes that due to the lack of correlation between total mercury in sediment, and mercury in largemouth bass tissue, BSAFs cannot be reliably used to calculate cleanup levels for sediment. EPA agrees with Olin's conclusions; however, notes that a BSAF could be calculated for methylmercury concentrations in sediment/pore water. EPA also agrees with Olin's statement that the amount of bioavailable mercury is likely limited by the mercury methylation rate. Therefore, EPA recommends that a model-based approach be used to develop total mercury cleanup levels in sediment. SERAFM, EPA's spreadsheet model is a logical choice for this. Whatever model is selected, it will be important to set cleanup levels not only for sediment concentrations, but also for largemouth bass fish tissue concentrations, and to monitor fish post-remediation to determine if clean up has adequately reduced methylation, and subsequent accumulation in the food chain. In the interim period, prior to agreeing to site-specific RGOs, EPA is looking carefully at Hg cleanup levels selected at other mercury contaminated sites, which are in the range of 0.5 – 1.0 ppm. At these sites, it appears that mercury methylation may not be substantially impacted (reduced) until total mercury levels are below these levels.

4.0 FEASIBILITY STUDY (Dated February 1996)

The dredging section of the 1996 Feasibility Study (FS) was reviewed and evaluated. The purpose of the review was to determine if the recommended dredging techniques and operations were appropriate given site constraints; and whether they need to be updated based upon current state-of-the-art practices. Five dredging-related areas were emphasized in the evaluation: methods, site requirements, environmental dredging techniques, sediment disposal, and overall cost.

Methods

The methods recommended in the FS were reviewed and evaluated with emphasis on capability and cost. Two methods were recommended; confined aquatic disposal (CAD) and on-Site brine well disposal. The CAD method involves filling geotextile bags onsite with a hydraulic dredge, and sinking the bags in the deeper section of the Site. The brine well disposal alternative involved pumping sediments from OU-2 to an abandoned brine-well on Olin property.

The same dredging consultants hired by Woodward-Clyde were contracted to review and update, if necessary, the two dredging techniques, as well as recommend improved dredge equipment or operations. Dr. Jack Fowler performed the review and evaluation of the CAD option. He is one of the premier experts on the use of geotextile bags for contaminated sediment disposal. Mike Duke, the inventor of DryDredge technology, provided input on the dredge plant design in the FS. Both of these consultants were involved in the formulation of the 1995 FS. Eric Seagren, a retired dredging consultant, provided the state-of-the-art in environmental dredging hardware and techniques.

Site Requirements

This topic area includes site sediment properties (density, water content, and sediment composition), mercury distribution in sediments, and estimates of total mercury removed as a function of dredging depth. These data were necessary for determining dredging plant selection and operation, as well as dredged material disposal options.

Environmental Dredging Techniques

The operation of a mechanical or hydraulic dredge in the OU-2 Site is constrained by the potential for sediment resuspension during dredging operations. The low-density sediments will have a tendency to resuspend due to the dredging action and dredge movement. Traditional dredging equipment can be applied; however, the dredge cycle must be altered to reduce the potential for sediment to mobilize. A dredging resuspension analysis was presented in the review, as well as recommendations for reducing the resuspension potential for different types of dredges.

Dredging Disposal Options

The FS dredging disposal options were evaluated (CAD and brine well), as well as the use of an upland confined disposal facility (CDF), which was not considered feasible in the FS. A potential CDF application was designed for the OU-2 application using US Army Corps of Engineers (USACE) software developed in the Environmental Laboratory at the Engineering Research and Development Center (ERDC) at Waterways Experiment Station.

Dredging Project Costs

The total project cost and cost descriptions were evaluated for the FS alternatives. For comparison purposes, the dredging consultants were asked to provide cost estimates for the dredging portion of the projects. A survey was conducted to determine the typical cost categories for contaminated sediment dredging projects, as well as actual costs given project information. From these data, a total dredging cost was estimated. It appears that the dredging cost estimate had categories that could not be validated.

Conclusions of the FS (Dredging Only) Review

The CAD option presented in the FS is not feasible. Dr. Jack Fowler indicated that the concept of filling geotextile bags on split-hull barges, and dumping them into the lake results in damaged or torn bags that will leak the contents. This was only a conceptual design and not proven in 1995.

The brine-well disposal option is cost prohibitive for the 70,000 cubic yards originally estimated; however, for a larger volume, it may be a viable option. The dredging and pumping operation is only a small fraction of the cost. The estimated preparation, operation, and monitoring of the brine well accounts for over 75 percent of the costs.

Pumping dredged material to an upland CDF is feasible for the Olin Site. However, because of the high clay content of the dredged slurries, the disposal area must be relatively large, with a high potential for treatment of the effluent.

The state-of-the-art practice for dredging and disposing of mercury sediments is to create an upland geotextile bag field. The bags are arranged in an excavated area, with each bag filled with dredged material from the lake site via pipeline. The bags filter out all the solids. The effluent is relatively clean thus there is no additional cost for secondary treatment. When the bag field is completed, the site is backfilled. This is the recommended disposal option, along with either a traditional hydraulic dredge or the original DryDredge presented in the FS.

EPA recommends that a Feasibility Study be submitted following current contaminated sediment guidance. In addition to monitored natural recovery (the enhanced sediment pilot project) and in-situ capping on which that the project team is currently working; EPA recommends reevaluation of environmental dredging and excavation in OU-2. EPA will submit recommendations for environmental dredging and excavation for the project team to review.

5.0 NATURE AND EXTENT OF CONTAMINATION

Adequate characterization of nature and extent of contamination in Basin sediment, floodplain soils, surface water, pore water, ground water, and biota is necessary for identifying areas of unacceptable risk, and evaluating remedial alternatives for ameliorating risk. The major questions related to nature and extent of contamination are:

- What is the nature and extent of total mercury, methylmercury, DDT and HCB contamination within OU-2 Basin and the floodplain?

- What is the nature and extent of total and methylmercury in surface and pore water within OU-2, and is there temporal variation associated with flood events, diel fluctuations, or seasonal conditions?

- Is GW beneath OU-2, acting as a source of Hg or other COCs to the Tombigbee River or to OU-2 sediments?

- What is the bioavailability of the COCs in OU-2?

There are a number of uncertainties related to current spatial distribution and vertical profile of mercury and DDT concentrations in sediment. The 1991/1992 data are important to the overall understanding of nature and extent because it had the most complete spatial coverage of any of the OU-2 sampling, and it represents the only sampling of the OU-2 floodplain. The 2006 ESPP Baseline Report suggests that, based upon 2006 samples, concentrations of total mercury have declined by approximately half since 1991, presumably due to the deposition of clean sediment in the basin. However, no 2006 samples were located in the northern third of the Embayment where historically high concentrations were located. Additional samples were added in this area in 2008 to address this data gap, but 2008 data has not yet been made available. A bubble plot illustrating concentrations of total mercury in surface sediment samples collected from 1991 through 2006 is shown in Figure 1. Olin prepared sediment contour maps for OU-2 Basin based upon the 2006 data. EPA prepared sediment contour maps for OU-2 Basin, Round Pond, and the floodplain based upon all data through 2006. The EPA contours were developed using Locfit software which uses local regression and likelihood methods to fit curves and surfaces to data. Comparison of Olin prepared contours versus EPA prepared contours for OU-2 Basin are shown in Figure 3. EPA prepared contours show higher concentrations and larger areas of elevated concentration throughout the Basin. EPA prepared contours of Round Pond and floodplain sediment data are shown in Figures 4 and 5, respectively.

Subsurface sediment was only sampled in 1991/1992 and 1995, with subsurface sediment samples collected at 8 locations in 1991/1992, and 5 locations in 1995. Additional cores may be required to refine the characterization of the vertical distribution of contaminants for evaluation of remedial alternatives and identification of remedial volumes, if the implications of accepting the uncertainties associated with interpretation of existing core data (i.e. the entire basin is likely unacceptably contaminated to a depth of 5ft) are too great for risk managers and decision makers to accept. Additional core data will also be necessary if validation is required of the current Olin hypothesis that natural processes are burying or reducing Hg concentrations over time through mixing with clean sediments.

Methylmercury analysis was only included in 1995 core samples and 2006 sediment, water, and biota, so no methylmercury data is available for the floodplain, or for the bulk of OU-2 Basin and biota samples. All current and future analyses are including methylmercury analysis in sediment, surface water, pore water, and biota, so this uncertainty is being addressed by current data collection and planning activities.

As previously mentioned, current conditions within the OU-2 floodplain are not characterized, and historical data are limited. No data have been collected in the floodplain since 1992. Though Hg concentrations in the floodplain were generally lower than in OU-2 Basin, EPA is concerned that historical floodplain concentrations were high enough for the floodplain to serve as a continuing source of methylmercury to OU-2 Basin, due to the seasonal wetting and drying of wetland soils. Additional data is needed to characterize current conditions within the floodplain and evaluate its potential to serve as a methylmercury source to the larger area.

Porewater sampling was conducted as part of the 1995 sediment core collection. Current information on COCs in porewater is lacking.

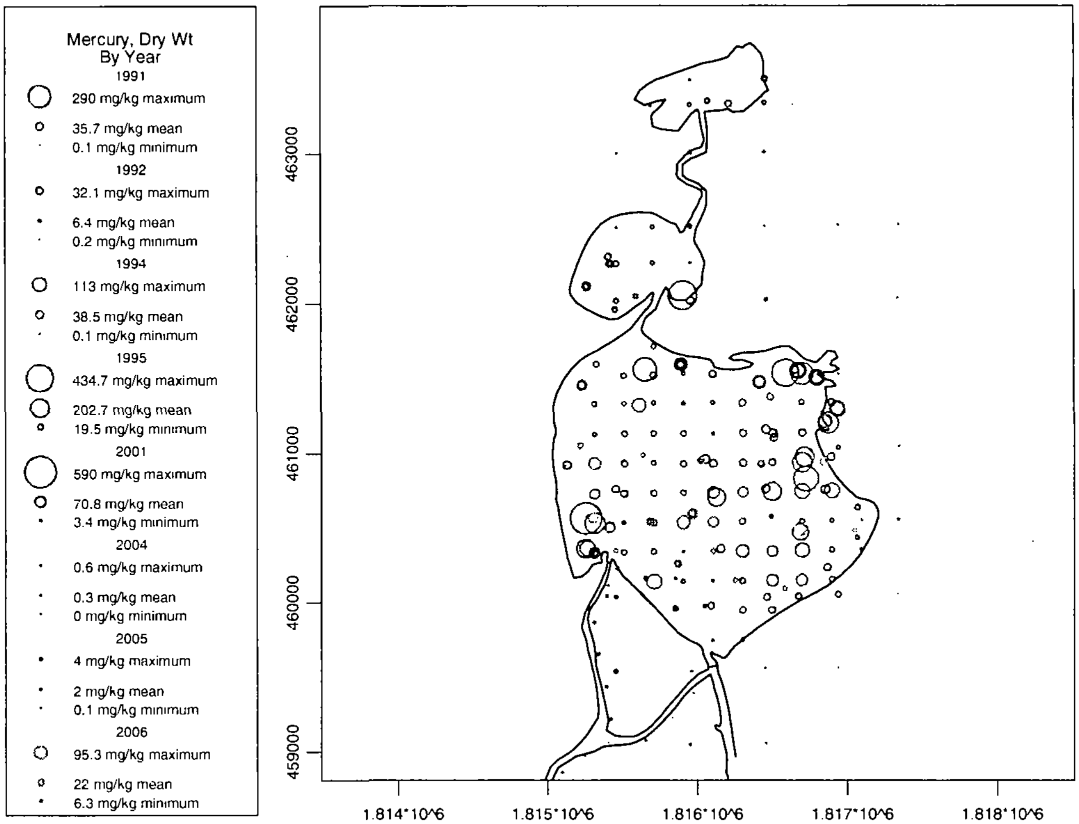

Figure 2. Bubble Plot of Total Hg Concentrations By Year (dry weight)

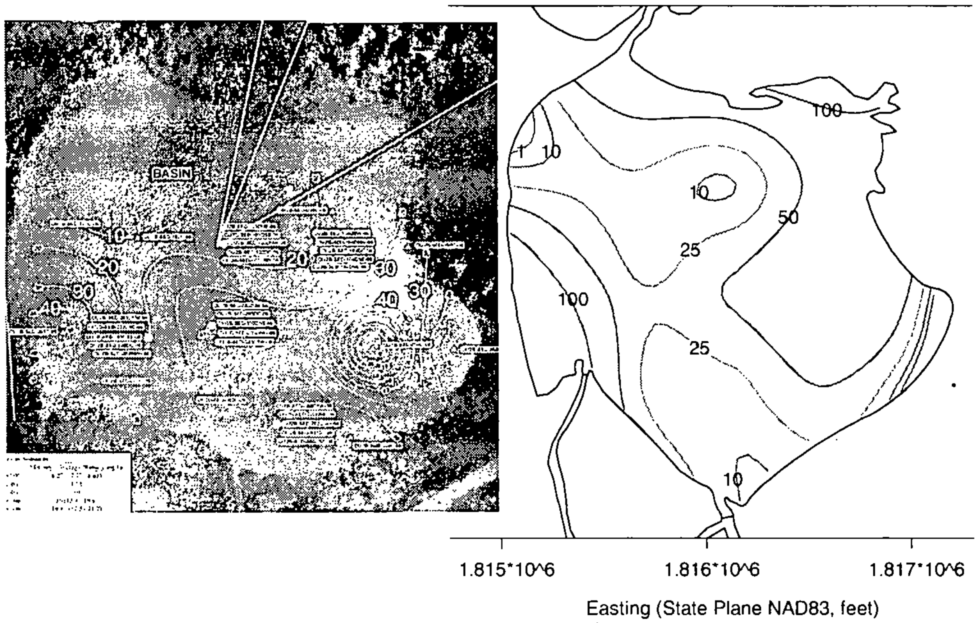

Figure 3. Comparison of 2006 Data Only Total Hg Contours (left) and All Years' Data Total Hg Contours (right) For OU-2 Basin (concentrations Dry Weight).

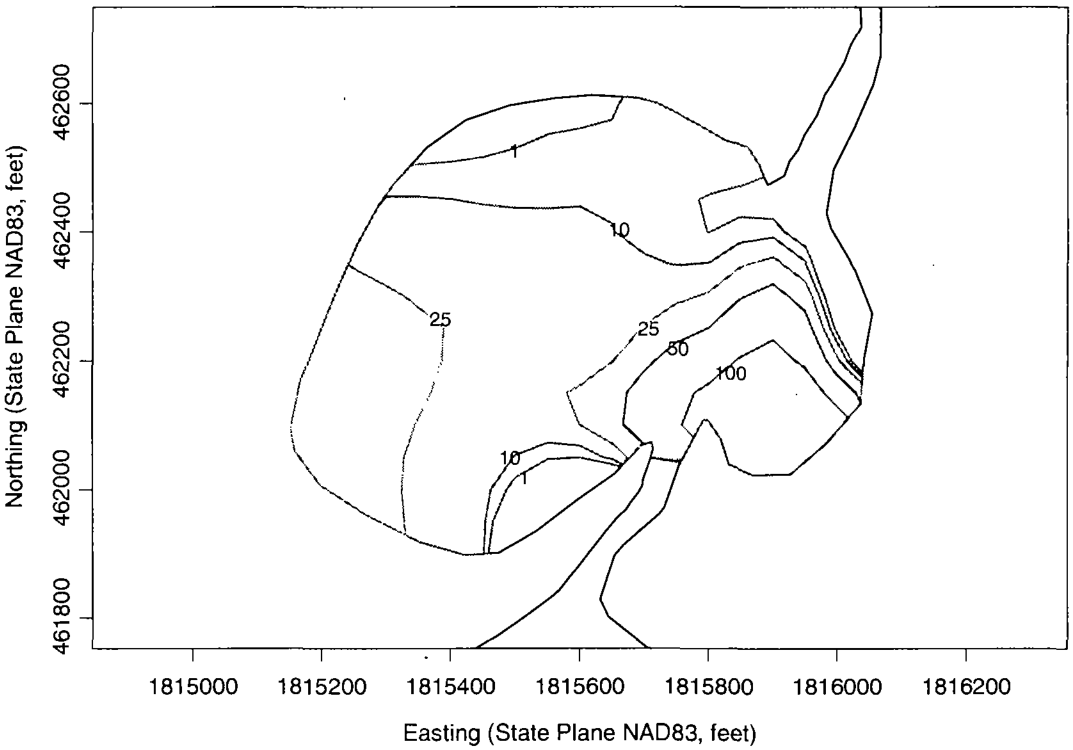

Figure 4. Isoconcentration Contours of Total Hg in Round Pond (Dry Weight, All Years' Data).

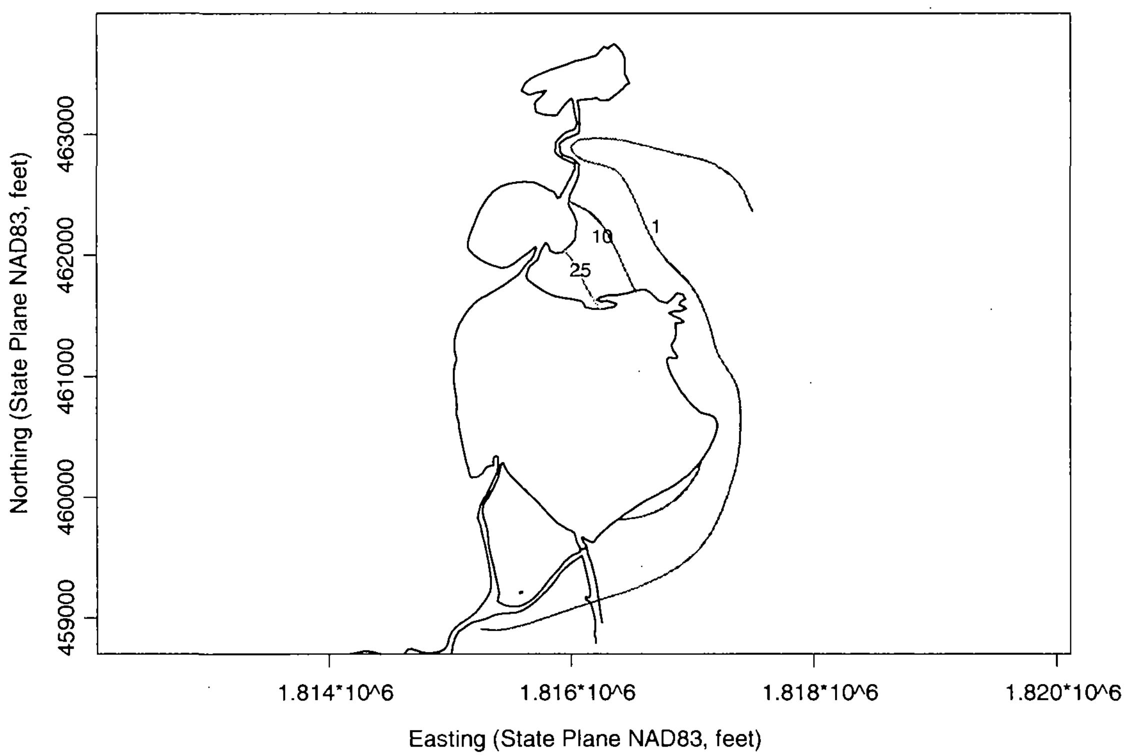

Figure 5. Isoconcentration Contours of Total Hg in Flood Plain Sediments (dry weight, 1992 data)

6.0 DATA GAPS AND CURRENT INFORMATION NEEDS

Based on the uncertainties identified during the review of historical reports, a number of uncertainties and associated informational needs were identified. These needs are summarized in Table 4. Issues which require the collection of additional data will need to be addressed through development of a supplemental data collection work plan with associated DQOs to ensure that data are sufficient to meet the investigation objectives.

Analysis of 2008 Olin Storm Water Sampling Data for Selected Locations in OU-2

December 3, 2008

US Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
(601) 634-2371

Analysis of 2008 Olin Storm Water Sampling Data For Selected Locations in OU-2

Prepared for

EPA Region 4

Prepared by

Stephen H. Scott, PhD, PE

US Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
River Engineering Branch
Sedimentation and Hydraulics Group
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

December 3, 2008

INTRODUCTION

Three high water events on the Tombigbee River were sampled for total suspended solids and size distribution in the Olin OU-2 site. The dates for these events were January 14, February 3 – 25, and August 25 – 28 of 2008. Eleven locations were sampled in OU-2 (Figure 1 and Table 1). These locations represented all sectors of the OU-2 lake, including the inflow channel just downstream of the gate (location 11). Samples were taken through a depth profile at each location.

TOMBIGBEE RIVER DISCHARGE AND WATER SURFACE ELEVATION

The Tombigbee River flow and water surface elevation (WSE) for these time periods are found in Figures 2 and 3 and Table 2. The January 14 event was a relatively low water event with a river discharge estimated to be < 10,000 cfs and a WSE of about 3.0 feet. The February event discharge ranged from about 20,000 cfs to 70,000 cfs with a WSE ranging from 4 feet to about 13 feet. The water surface elevations are approximate, resulting from a regression analysis comparing measured Olin dock WSE to the upstream Leroy gauge. It was observed that the OU-2 berm with a top elevation of 12 feet was not overtopped during this event, thus the river WSE estimation was overestimated using the regression equation (Figure 3). The August event had a peak discharge of about 46,000 cfs and a peak WSE of just above 6.0 feet. Note that on the discharge plot, the approximate river peak WSE is provided over the approximate event time span, whereas on the WSE plot the peak river discharge is provided over the event time span.

DATA ANALYSIS AND COMMENTS

Figures 4 – 14 present the total suspended sediment (TSS) concentrations as a function of depth for the eleven sample locations (Figure 1 and Table 1). All three flood events are included in the plots. Additionally, under each plot are the summary statistics for the data set presented in the plot. The data indicate a relatively uniform distribution of total solids concentration throughout the site. Location 1, which is sited just off the entrance channel, shows an increase in TSS (peak 200 mg/l) at a depth of about five feet. Additionally, location 2 has a single very high TSS sample at a depth of about nine feet (450 mg/l). However, for the majority of the locations and depths, the TSS concentration falls between 10 to 40 mg/l. All of the sample locations and flood events are shown in Figure 15. The average TSS for all locations and events is about 22 mg/l.

Figures 16 – 18 depict the TSS by flood event. The January 2008 event (Figure 16) was not significant, thus the TSS concentrations in the site were probably background concentrations (approximately 5 – 10 mg/l). The highest average TSS concentration was for the August event (approximately 26 mg/l).

Figure 19 presents the estimated cap thickness in the site as a function of water depth. This calculation assumes an average TSS concentration of 22 mg/l uniformly distributed throughout the lake, and an assumed cap density of 1282 kg/cu m. Figure 20 presents the cap thickness calculation as a function of depth contours. The deepest portion of the lake has a computed cap thickness of about 0.7 mm, while the shallow fringe areas are on the order of 0.1 mm or less.

The sediment rating curve for the Tombigbee River at Olin Dock is found in Figure 21. These data were collected over two years (2005 – 2006) with an automated ISCO water sampler sited at elevation 6.0 feet. For the February and August TSS sampling events (70,000 and 46,000 cfs respectively), the central tendency of the data in Figure 21 indicates a river TSS of about 60 mg/l. Therefore, less than half of the river TSS was available to the OU-2 site through the gated structure (22 mg/l average in OU-2).

In addition to the TSS data, a number of suspended sediment samples were analyzed for grain size distribution for the August flood event. The following sediment size ranges were analyzed: 0.5 – 2.0 micron, 2.0 – 25.0 micron, and > 25.0 micron. The > 25.0 micron range includes the silt sizes, whereas the other ranges represent clays. Figures 22 – 26 show the total silt and clay fractions, as well as the clay and silt sediment size ranges for locations 1, 3, 6, 9, and 11. The silt fraction dominates, however it decreases with distance from the entrance channel (gate location). The silt fraction ranges from 70 to 53 percent from the entrance channel (location 11) to the north western sampling location in OU-2 (location 9).

LIST OF TABLES

Table 1. Sampling locations (NAD 87 State Plane)

Location	Easting	Northing
1	1816057	460161
2	1815682	460600
3	1816058	460562
4	1816652	460559
5	1815779	461072
6	1816060	460962
7	1816711	461205
8	1815364	460980
9	1815569	461409
10	1816510	461228
11	1816147	459506

Table 2. Tombigbee River flood events

Date	Peak Discharge - cfs	* Peak WSE - ft
1/14/2008	< 10,000	3.0
2/3/2008 – 2/25/2008	70,000	12.0
8/25/2008 – 8/28/2008	46,000	6.0

* - Estimated from regression fit to USGS Leroy gauge

LIST OF FIGURES

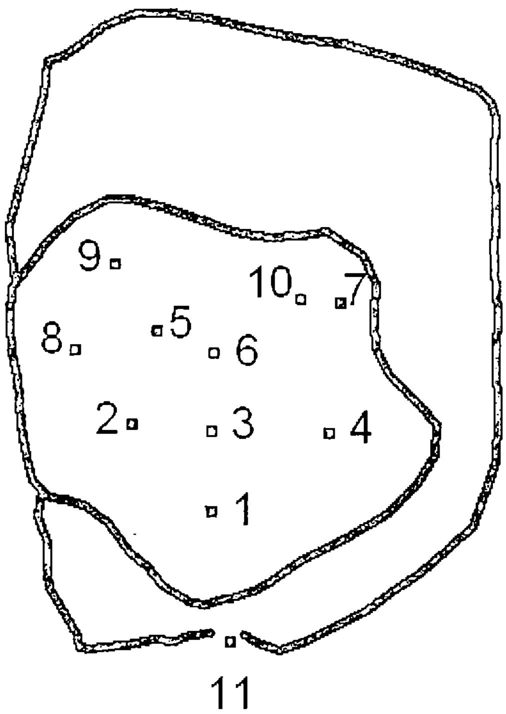

Figure 1. Sampling locations in OU-2 lake area

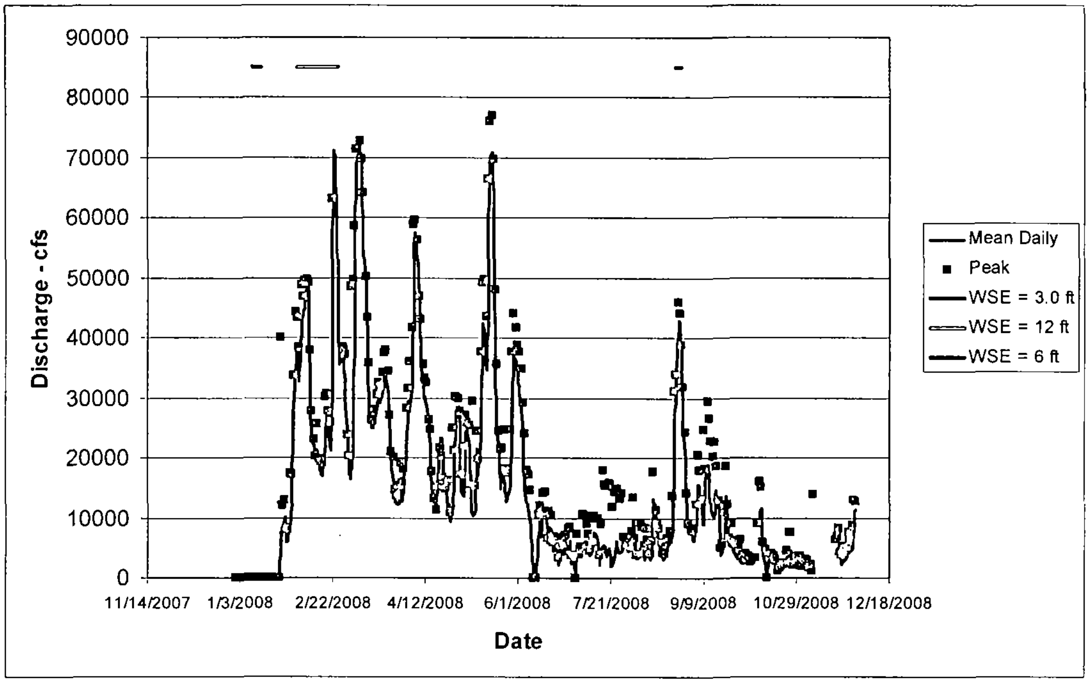

Figure 2. Discharge and peak discharge for January – November 2008

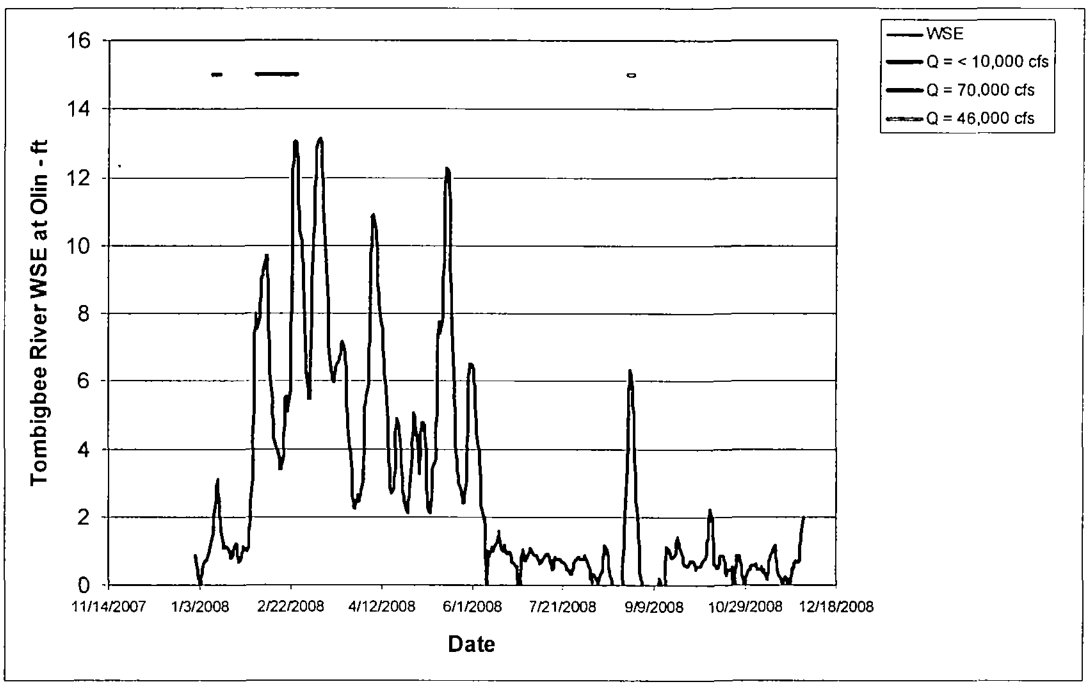

Figure 3. Tombigbee River WSE for January - November 2008

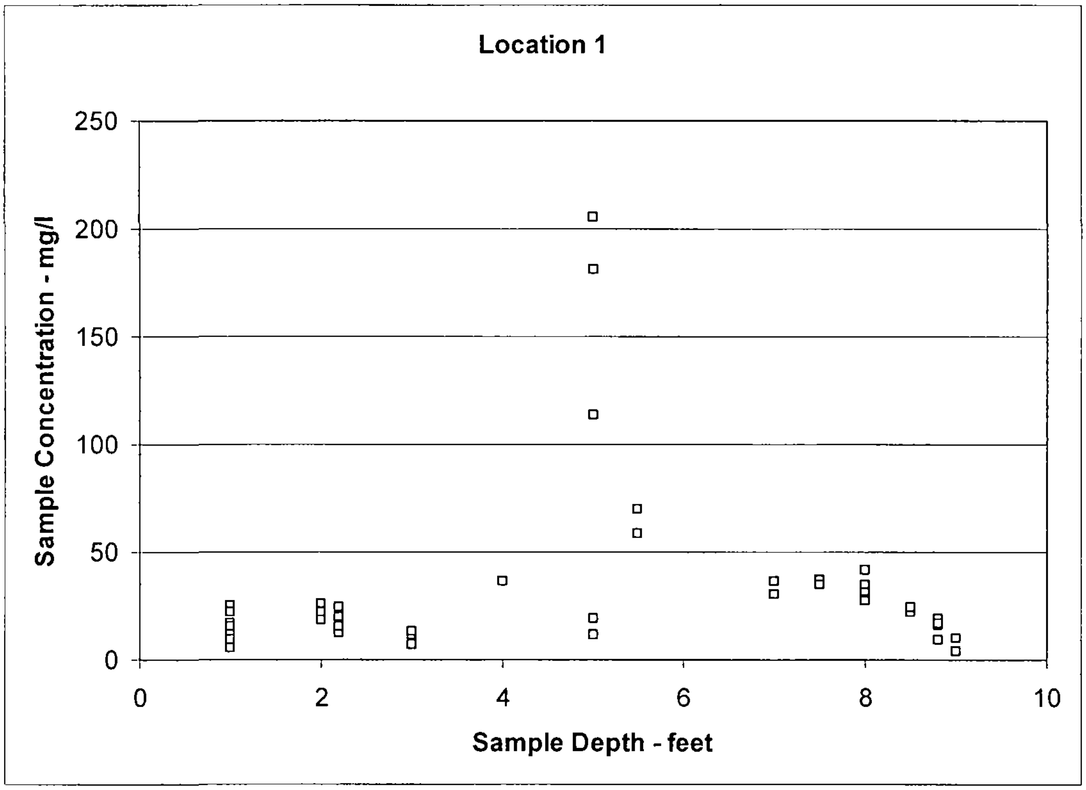

Figure 4. Sample concentration as a function of depth for all events at location 1. Summary data statistics provided below

	Column1
Mean	34.30434783
Standard Error	6.068200918
Median	22
Mode	17
Standard Deviation	41.15654103
Sample Variance	1693.86087
Kurtosis	9.182254511
Skewness	2.986749281
Range	201
Minimum	4
Maximum	205
Sum	1578
Count	46
Confidence Level(95.0%)	12.22198385

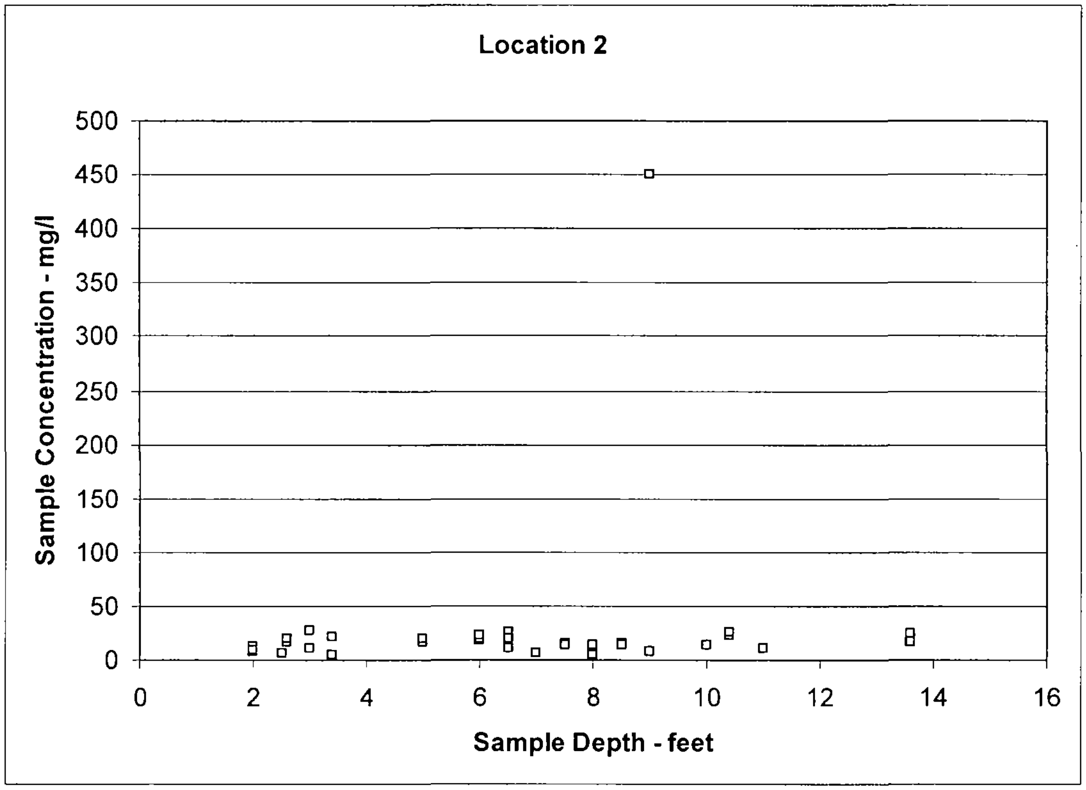

Figure 5. Sample concentration as a function of depth for all events at location 2. Summary data statistics provided below

Column1	
Mean	27.43243243
Standard Error	11.78431928
Median	16
Mode	13
Standard Deviation	71.68121579
Sample Variance	5138.196697
Kurtosis	36.37217608
Skewness	6.007120797
Range	446
Minimum	4
Maximum	450
Sum	1015
Count	37
Confidence Level(95.0%)	23.89970708

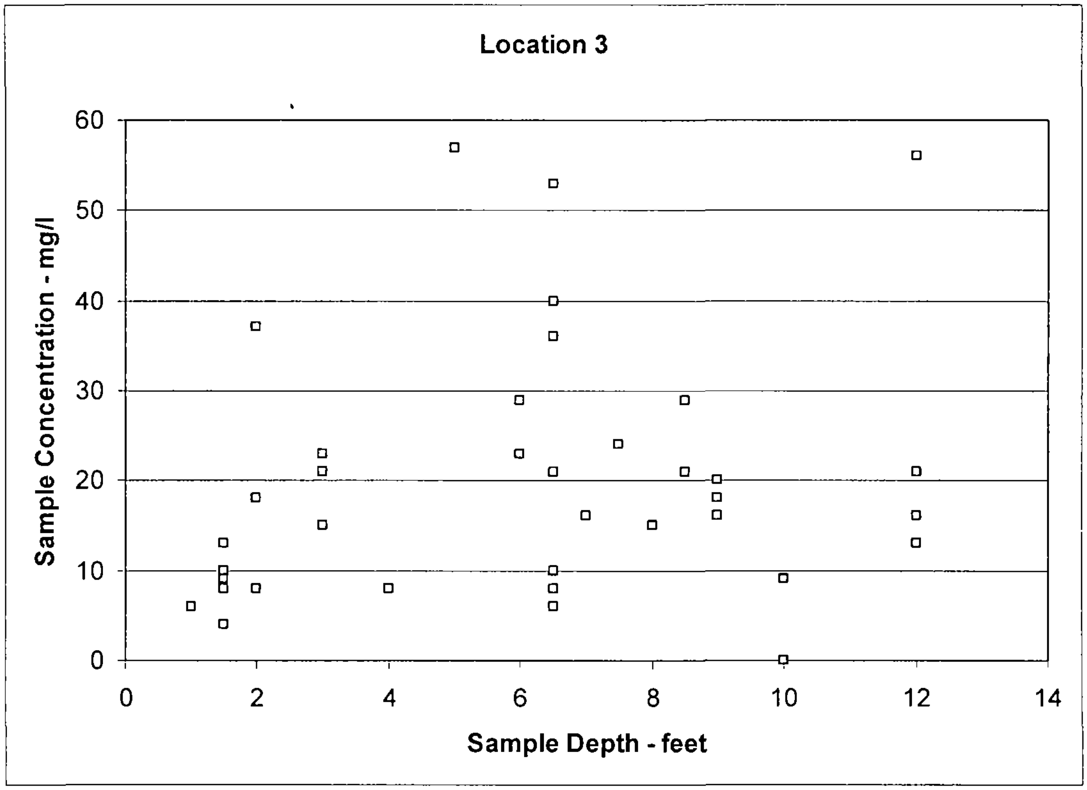

Figure 6. Sample concentration as a function of depth for all events at location 3. Summary data statistics provided below

	Column1
Mean	21.025
Standard Error	2.337127181
Median	18
Mode	8
Standard Deviation	14.78129015
Sample Variance	218.4865385
Kurtosis	0.96853562
Skewness	1.220457261
Range	57
Minimum	0
Maximum	57
Sum	841
Count	40
Confidence Level(95.0%)	4.727285885

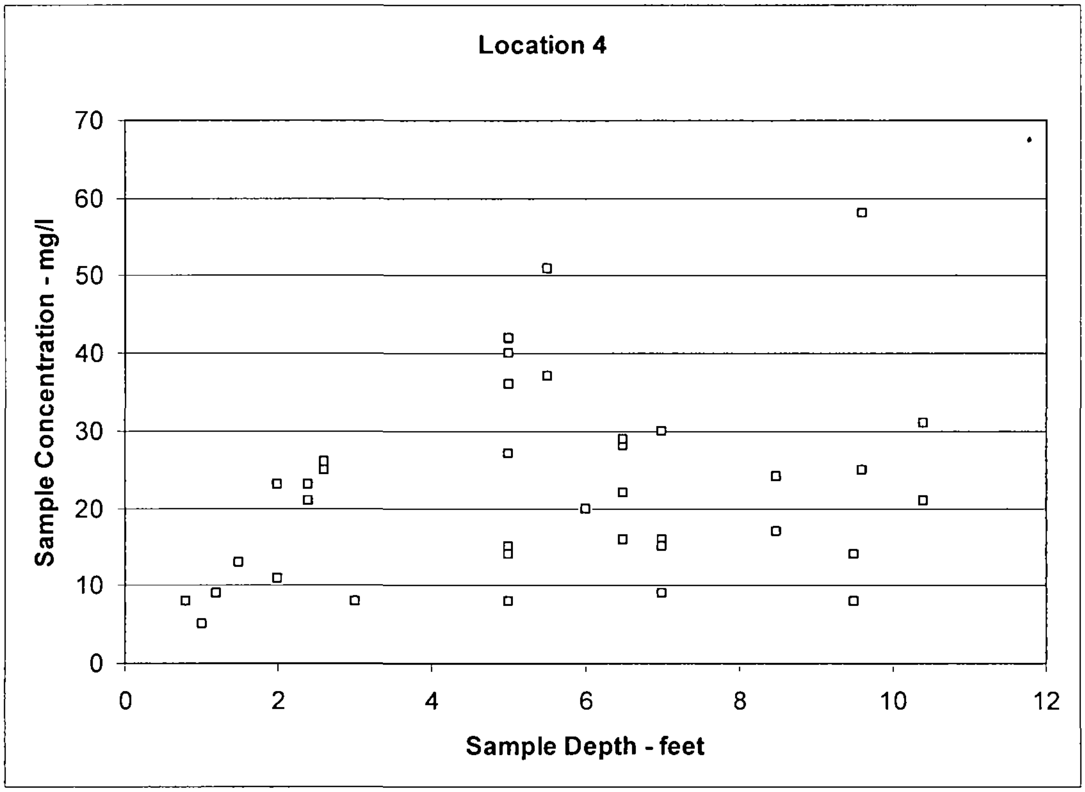

Figure 7. Sample concentration as a function of depth for all events at location 4. Summary data statistics provided below

	Column1
Mean	22.2972973
Standard Error	2.034929541
Median	21
Mode	8
Standard Deviation	12.37799316
Sample Variance	153.2147147
Kurtosis	0.940487636
Skewness	0.983360945
Range	53
Minimum	5
Maximum	58
Sum	825
Count	37
Confidence Level(95.0%)	4.127028365

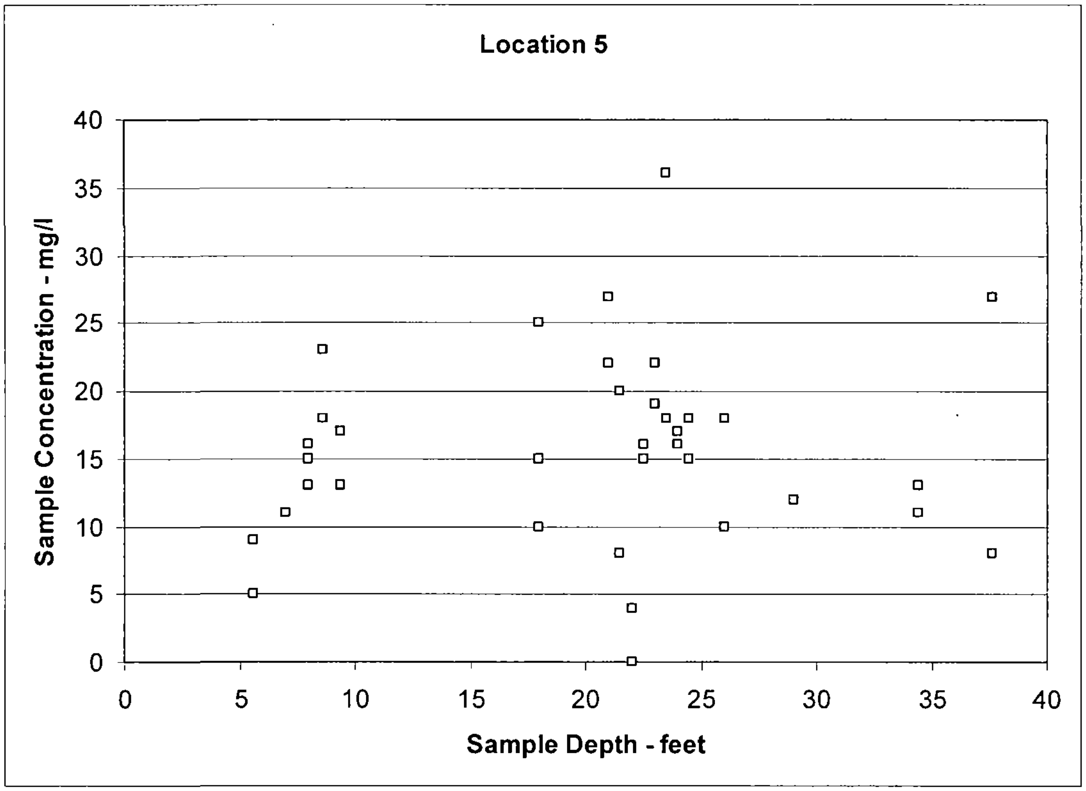

Figure 8. Sample concentration as a function of depth for all events at location 5. Summary data statistics provided below

Column1	
Mean	15.61111111
Standard Error	1.178024832
Median	15.5
Mode	15
Standard Deviation	7.068148991
Sample Variance	49.95873016
Kurtosis	1.117568497
Skewness	0.426654577
Range	36
Minimum	0
Maximum	36
Sum	562
Count	36
Confidence Level(95.0%)	2.391517536

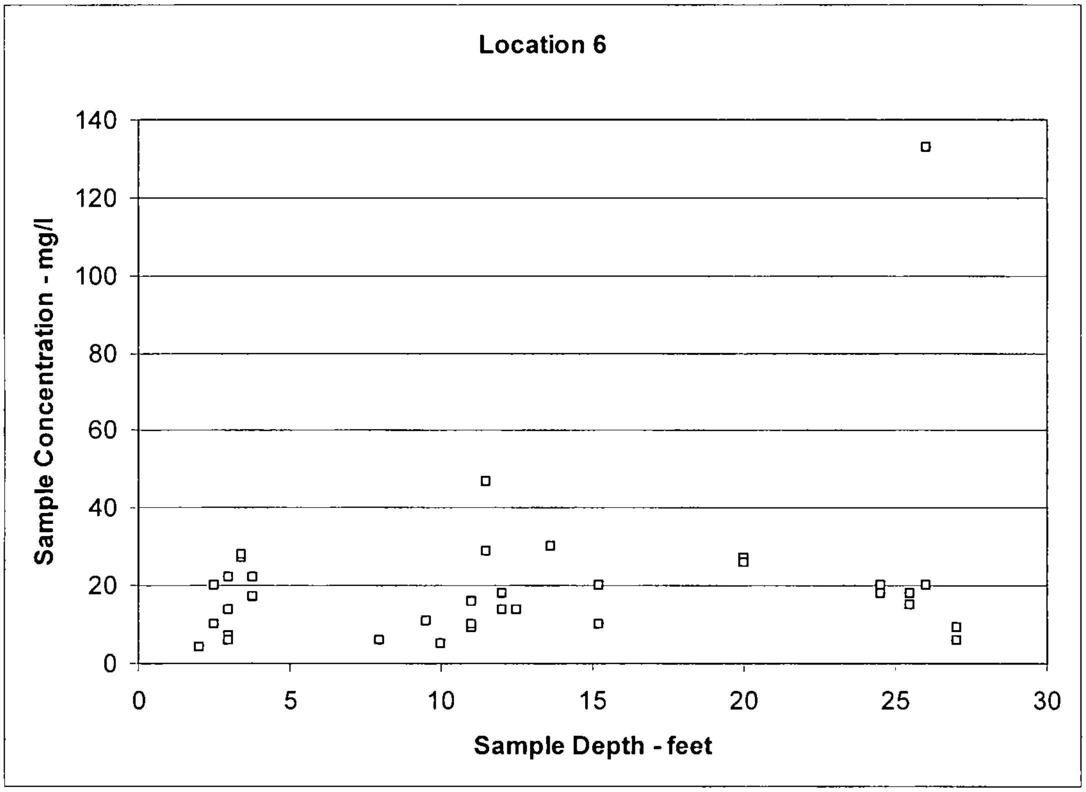

Figure 9. Sample concentration as a function of depth for all events at location 6. Summary data statistics provided below

Column1	
Mean	20.22857143
Standard Error	3.656945898
Median	17
Mode	20
Standard Deviation	21.6347837
Sample Variance	468.0638655
Kurtosis	22.76560559
Skewness	4.403990105
Range	129
Minimum	4
Maximum	133
Sum	708
Count	35
Confidence Level(95.0%)	7.43180818

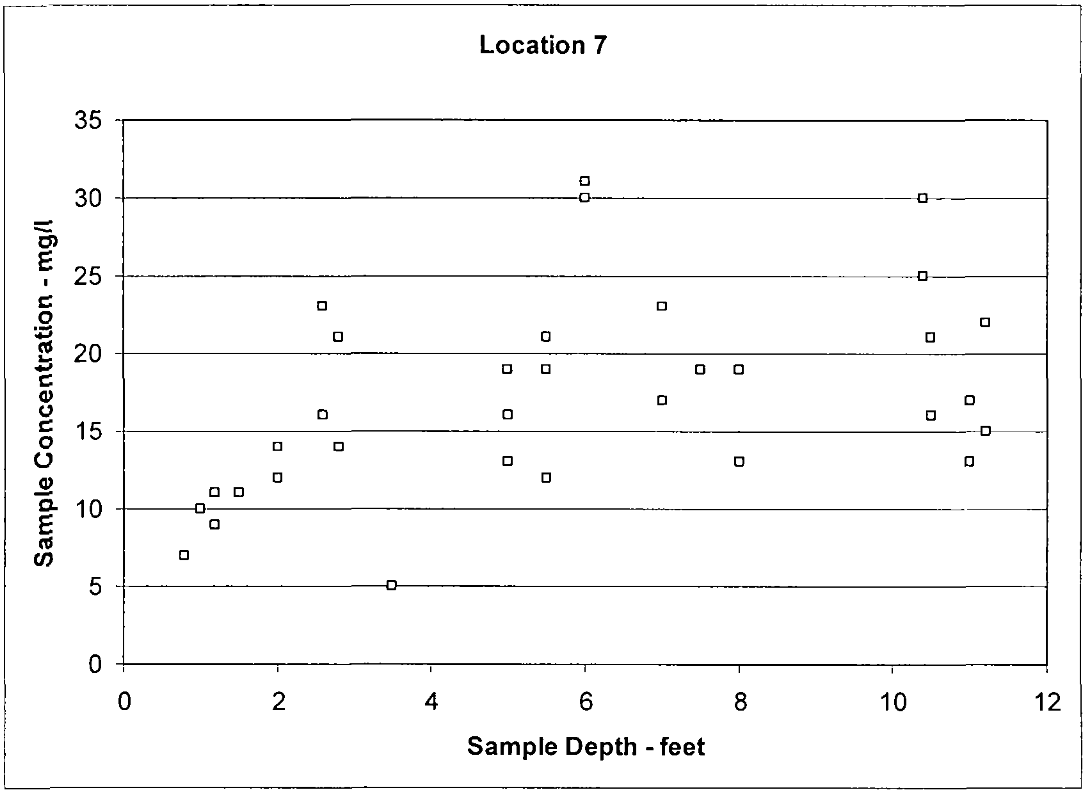

Figure 10. Sample concentration as a function of depth for all events at location 7. Summary data statistics provided below

Column1	
Mean	17.25714286
Standard Error	1.063008935
Median	17
Mode	19
Standard Deviation	6.288845668
Sample Variance	39.54957983
Kurtosis	-0.069155687
Skewness	0.387177121
Range	26
Minimum	5
Maximum	31
Sum	604
Count	35
Confidence Level(95.0%)	2.160294059

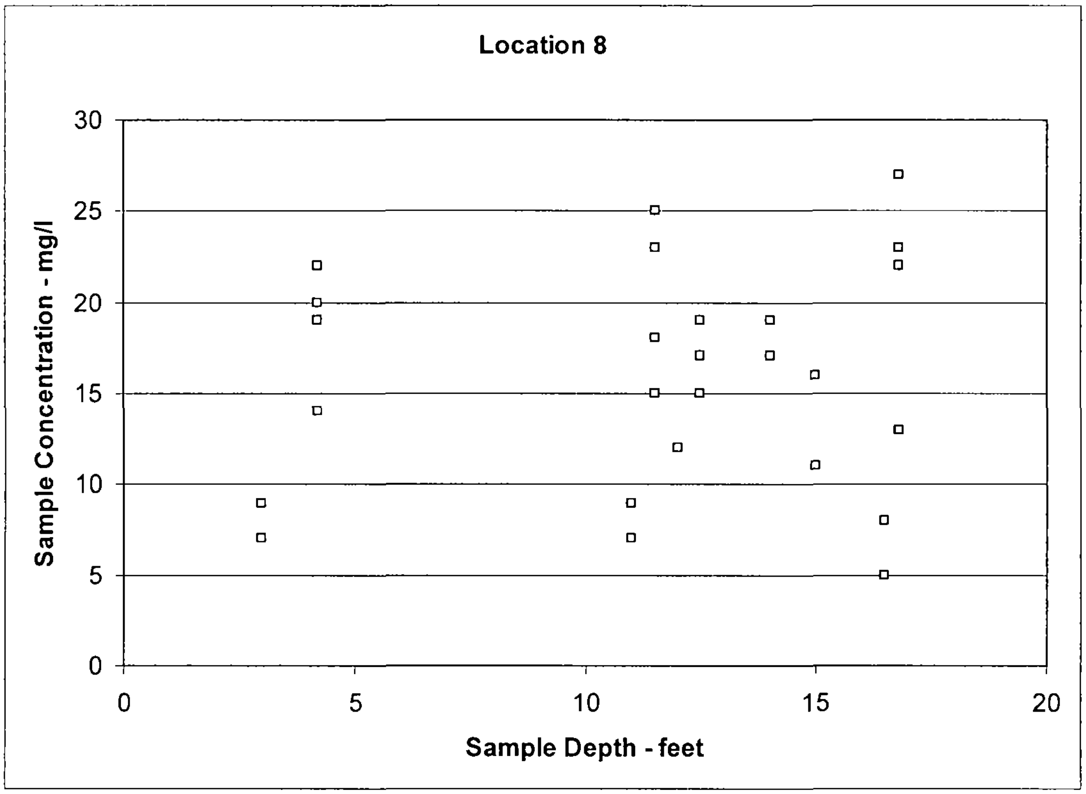

Figure 11. Sample concentration as a function of depth for all events at location 8. Summary data statistics provided below

Column1	
Mean	15.63333333
Standard Error	1.07477165
Median	16.5
Mode	7
Standard Deviation	5.886766769
Sample Variance	34.65402299
Kurtosis	-0.80122046
Skewness	-0.089477219
Range	22
Minimum	5
Maximum	27
Sum	469
Count	30
Confidence Level(95.0%)	2.198154804

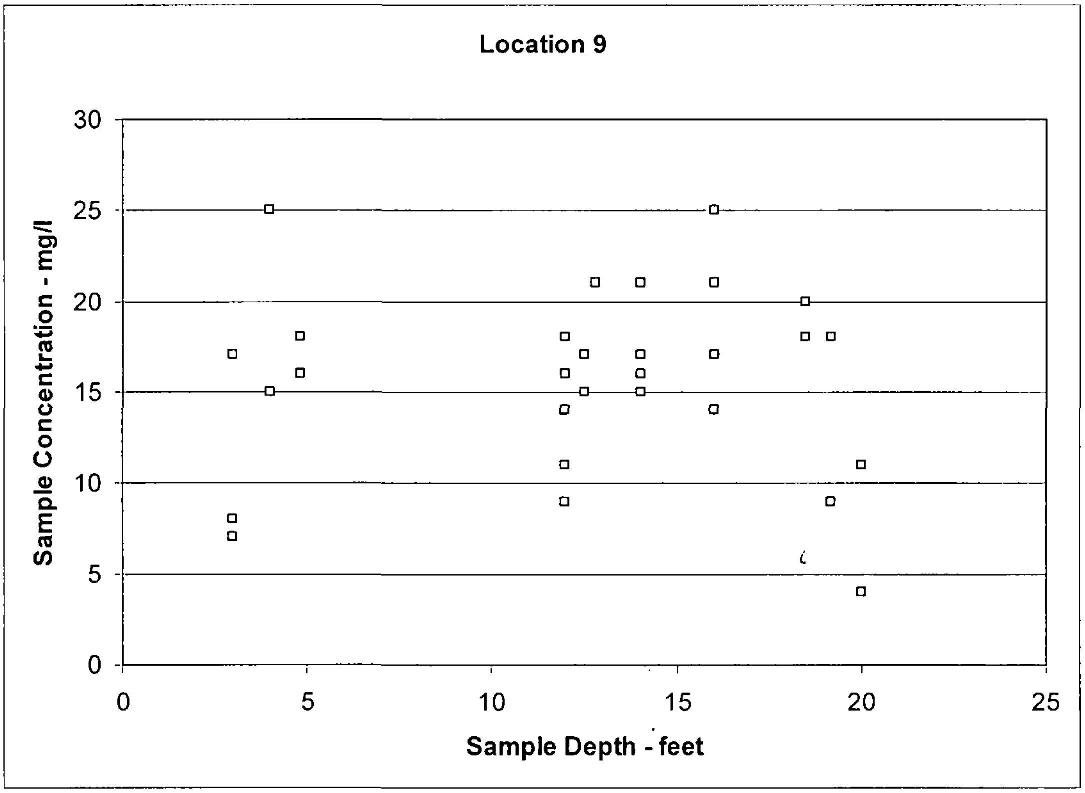

Figure 12. Sample concentration as a function of depth for all events at location 9. Summary data statistics provided below

Column1	
Mean	15.62068966
Standard Error	0.93957043
Median	16
Mode	17
Standard Deviation	5.059741616
Sample Variance	25.60098522
Kurtosis	0.05324709
Skewness	-0.347579841
Range	21
Minimum	4
Maximum	25
Sum	453
Count	29
Confidence Level(95.0%)	1.924622755

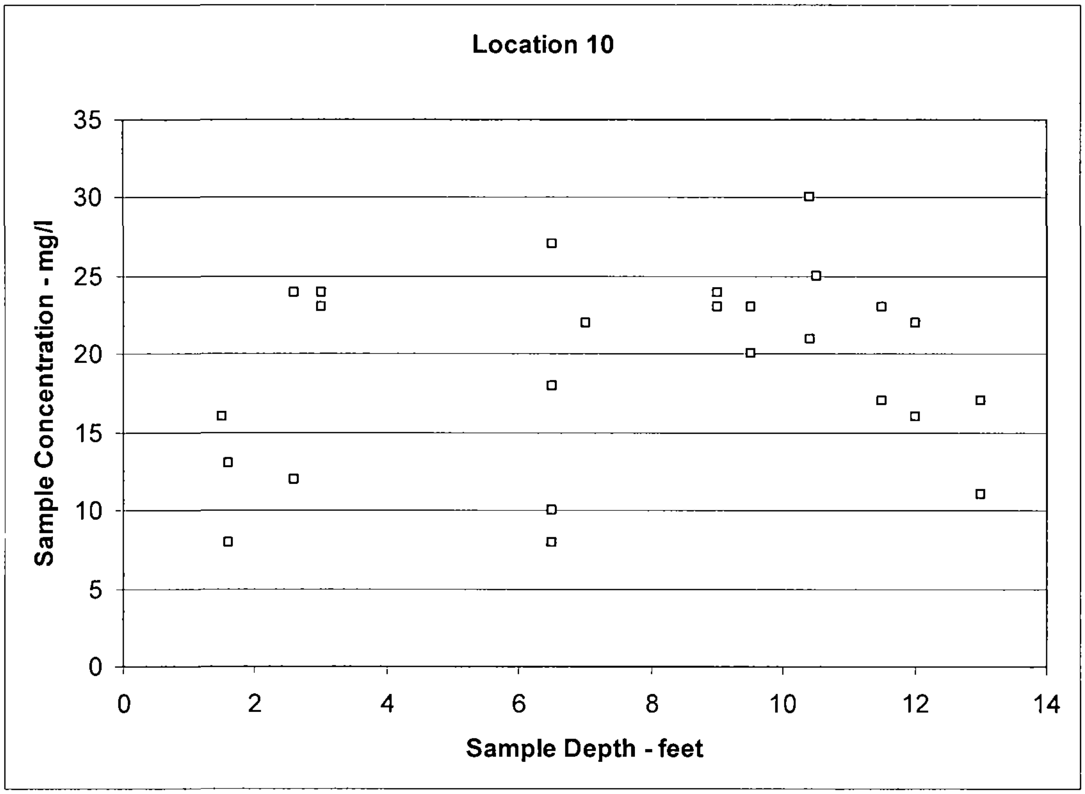

Figure 13. Sample concentration as a function of depth for all events at location 10. Summary data statistics provided below

Column1	
Mean	19.35714286
Standard Error	1.105797954
Median	21.5
Mode	23
Standard Deviation	5.851332775
Sample Variance	34.23809524
Kurtosis	-0.553373903
Skewness	-0.50365309
Range	22
Minimum	8
Maximum	30
Sum	542
Count	28
Confidence Level(95.0%)	2.268909962

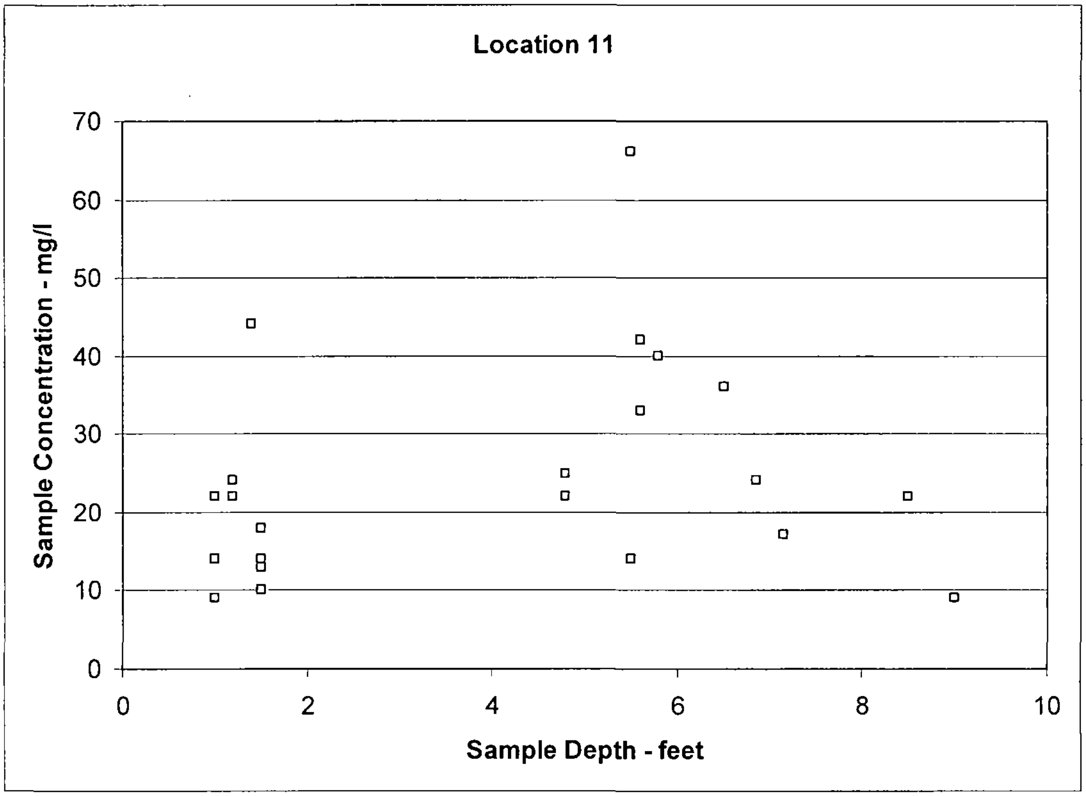

Figure 14. Sample concentration as a function of depth for all events at location 11. Summary data statistics provided below

Column1	
Mean	26
Standard Error	2.917339467
Median	22
Mode	22
Standard Deviation	14.2919862
Sample Variance	204.2608696
Kurtosis	0.976570773
Skewness	1.036159511
Range	57
Minimum	9
Maximum	66
Sum	624
Count	24
Confidence Level(95.0%)	6.034976456

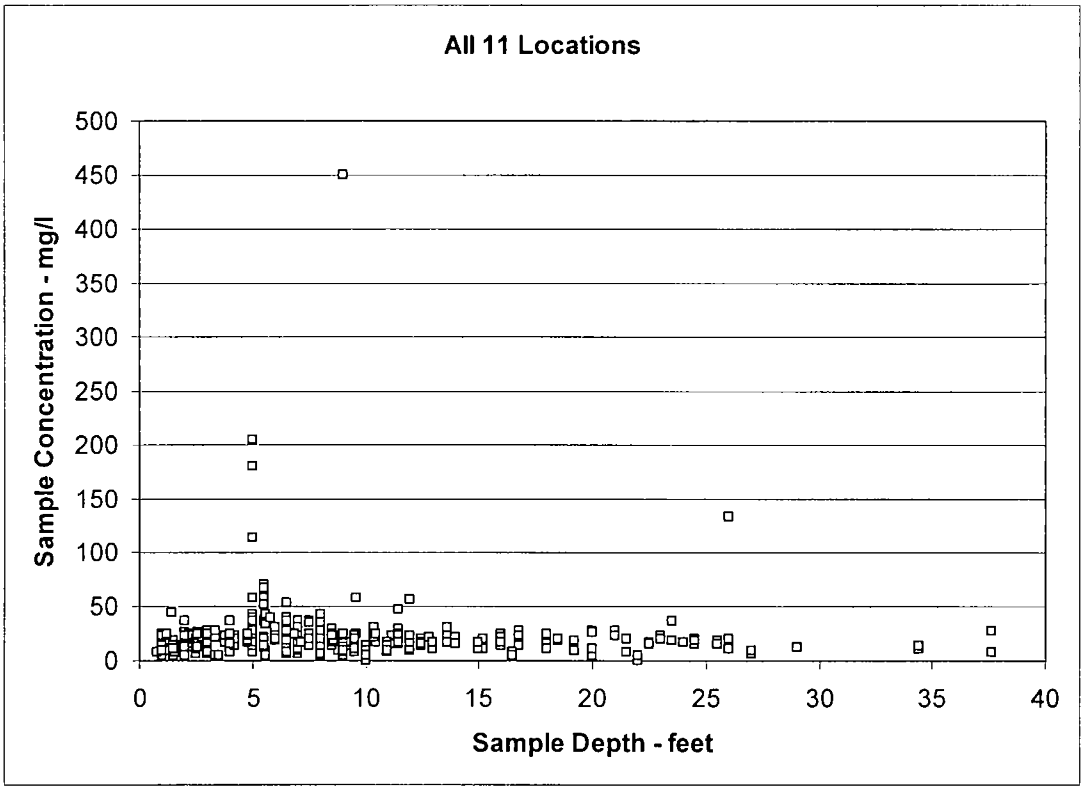

Figure 15. Sample concentration as a function of depth for all events and all 11 locations. Summary data statistics provided below

Mean	21.80636605
Standard Error	1.490731909
Median	18
Mode	17
Standard Deviation	28.94477798
Sample Variance	837.8001721
Kurtosis	134.453382
Skewness	10.13801628
Range	450
Minimum	0
Maximum	450
Sum	8221
Count	377
Confidence Level(95.0%)	2.931215949

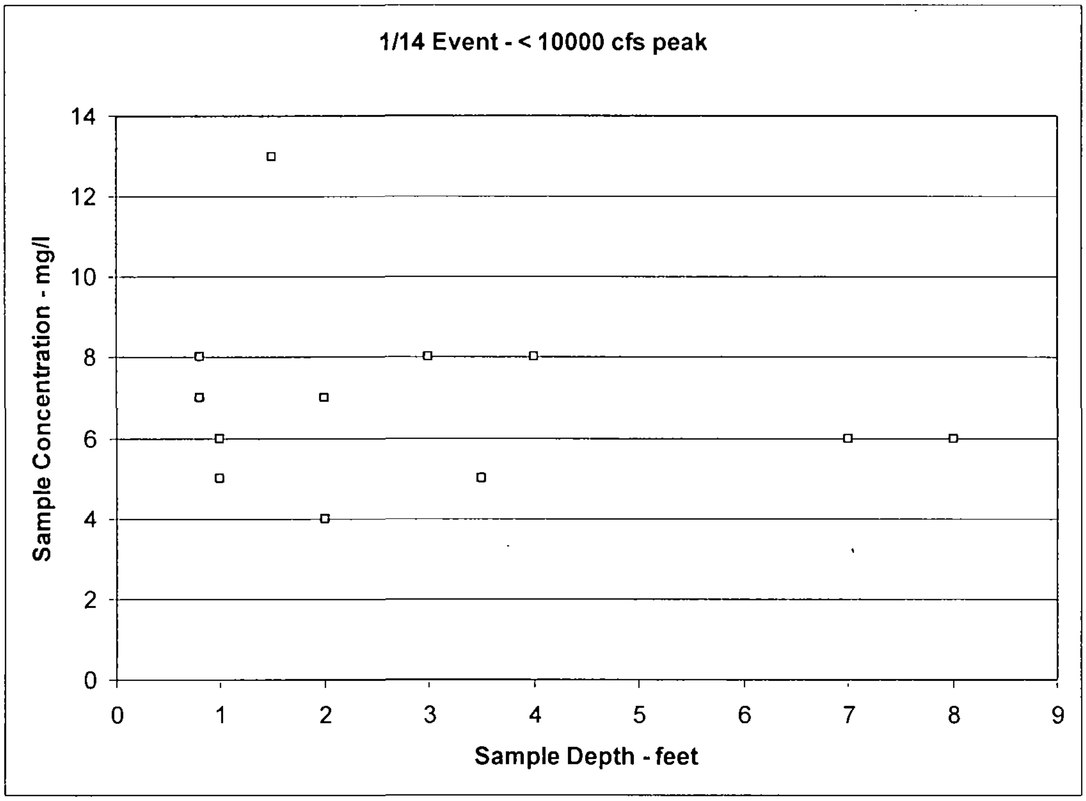

Figure 16. Sample concentration as a function of depth for event 1, all locations. Summary data statistics provided below

	Column1
Mean	6.916666667
Standard Error	0.668085611
Median	6.5
Mode	6
Standard Deviation	2.314316445
Sample Variance	5.356060606
Kurtosis	4.069310532
Skewness	1.652221063
Range	9
Minimum	4
Maximum	13
Sum	83
Count	12
Confidence Level(95.0%)	1.47044726

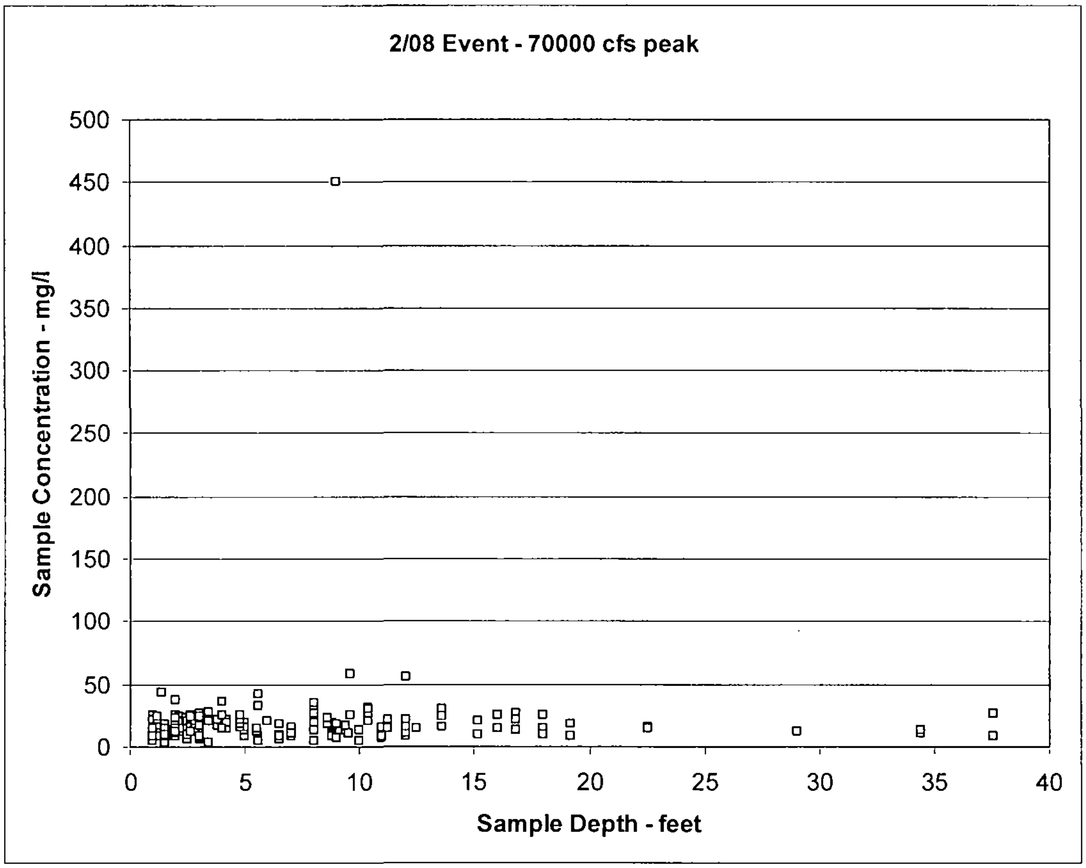

Figure 17. Sample concentration as a function of depth for event 2, all locations. Summary data statistics provided below

	Column1
Mean	19.23902439
Standard Error	2.195258617
Median	16
Mode	13
Standard Deviation	31.43132007
Sample Variance	987.9278814
Kurtosis	175.0785472
Skewness	12.7574583
Range	446
Minimum	4
Maximum	450
Sum	3944
Count	205
Confidence Level(95.0%)	4.328307407

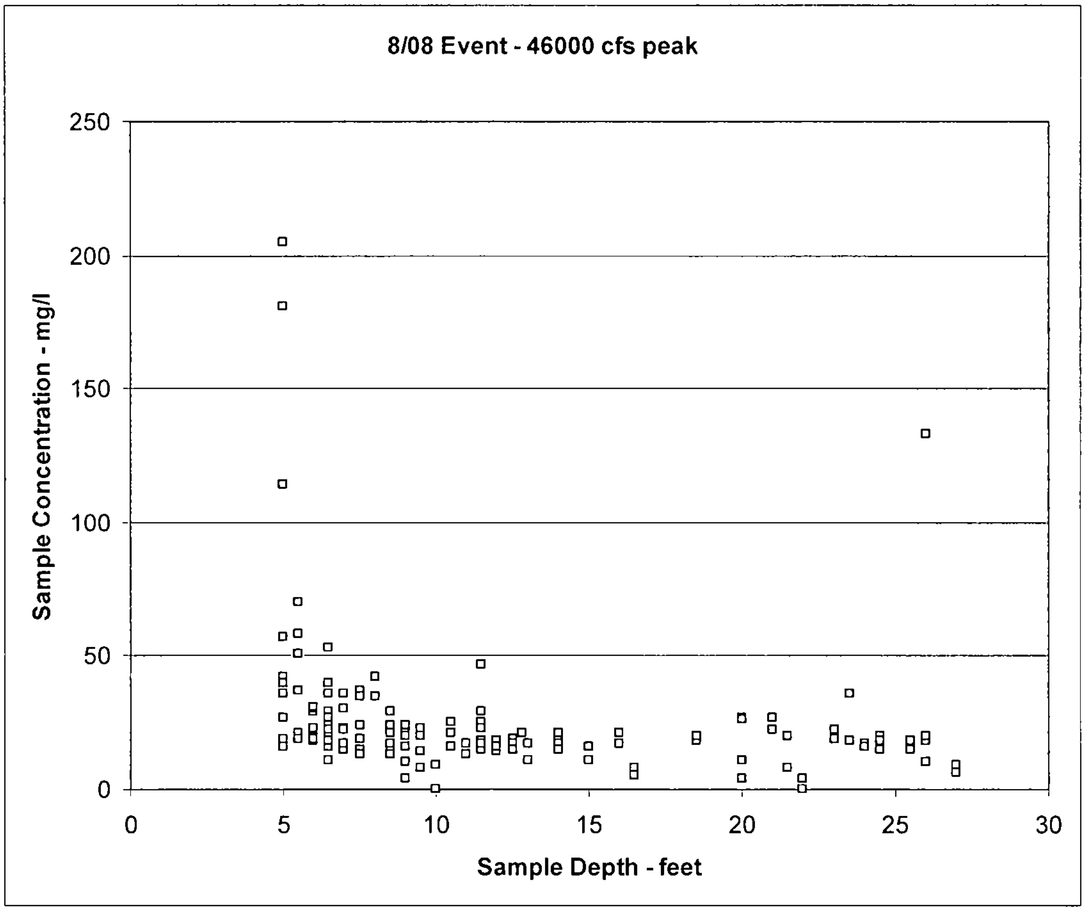

Figure 18. Sample concentration as a function of depth for event 3, all locations. Summary data statistics provided below

	Column1
Mean	25.92105263
Standard Error	2.126848863
Median	20
Mode	17
Standard Deviation	26.22155382
Sample Variance	687.569885
Kurtosis	24.19763302
Skewness	4.514893524
Range	205
Minimum	0
Maximum	205
Sum	3940
Count	152
Confidence Level(95.0%)	4.20222784

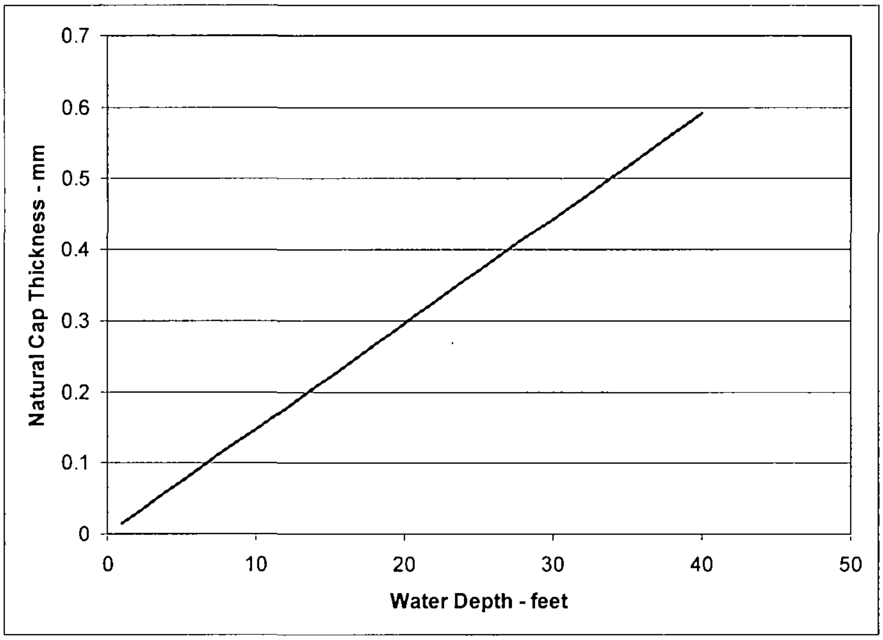

Figure 19. Natural cap thickness as a function of depth assuming a homogeneous suspended sediment concentration of 22.0 mg/l in the water column and an assumed final bed bulk density of 1281 kg/cu m.

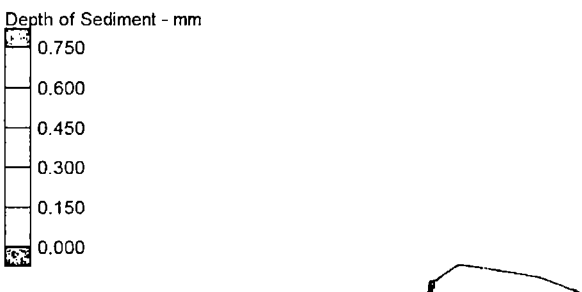

Figure 20. Cap thickness contours over the OU-2 lake area assuming a homogeneous suspended sediment concentration of 22.0 mg/l in the water column and an assumed final bed bulk density of 1281 kg/cu m.

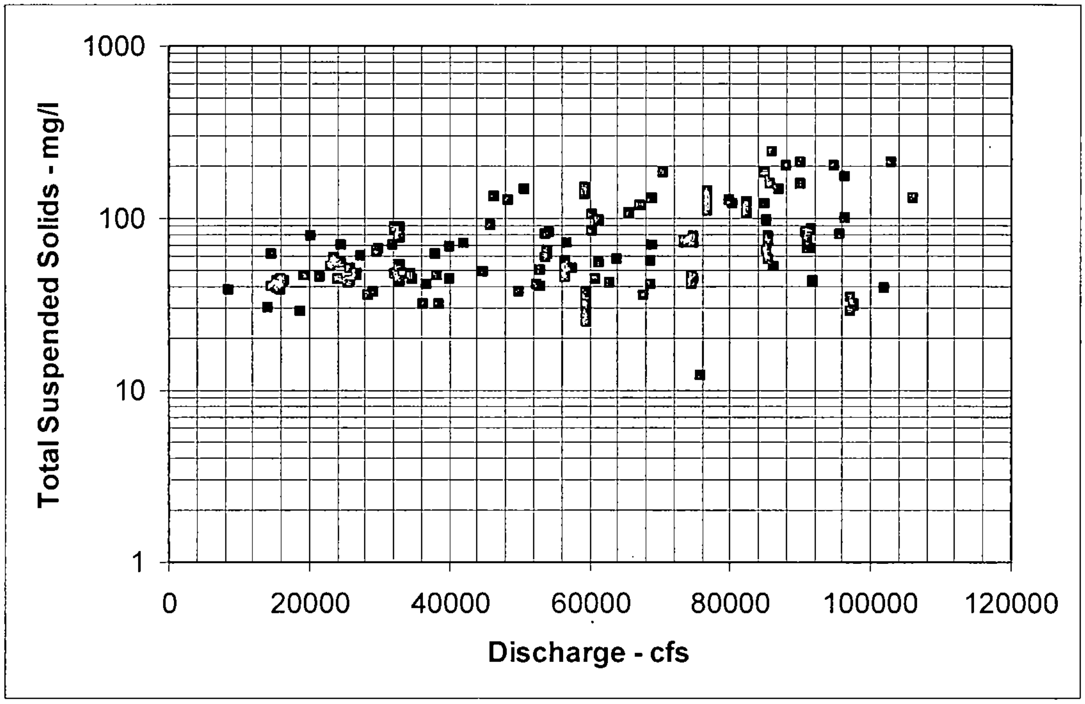

Figure 21. Sediment rating curve for Olin dock area on Tombigbee River

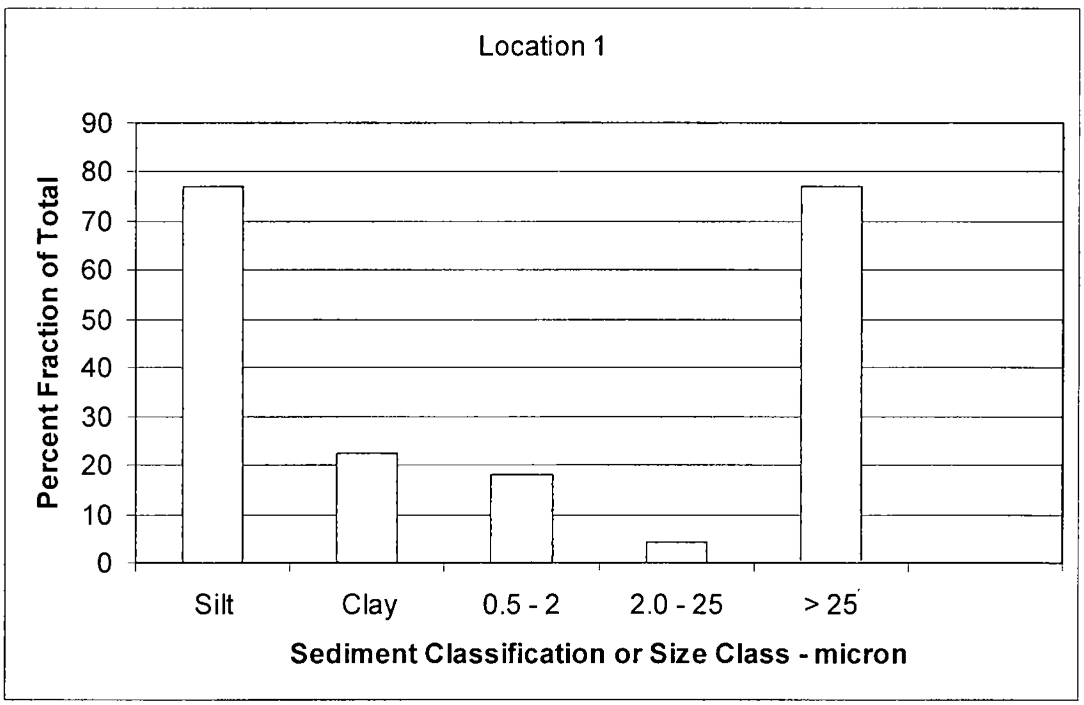

Figure 22. Suspended sediment size fractions for location 1 – average of all depths

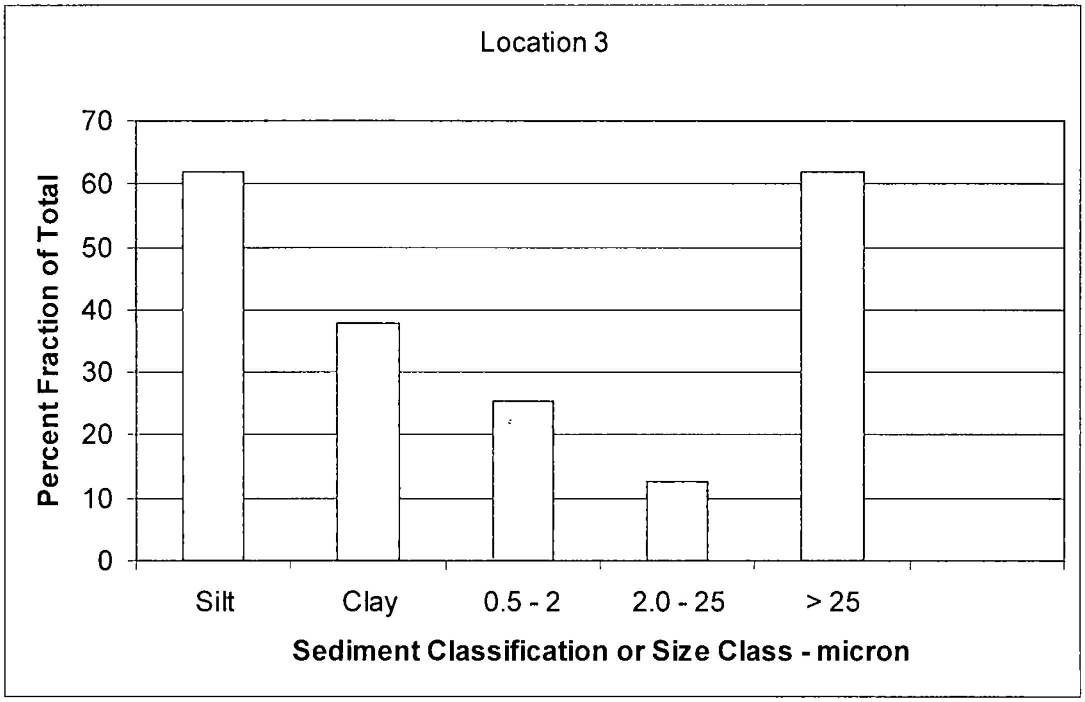

Figure 23. Suspended sediment size fractions for location 3 – average of all depths

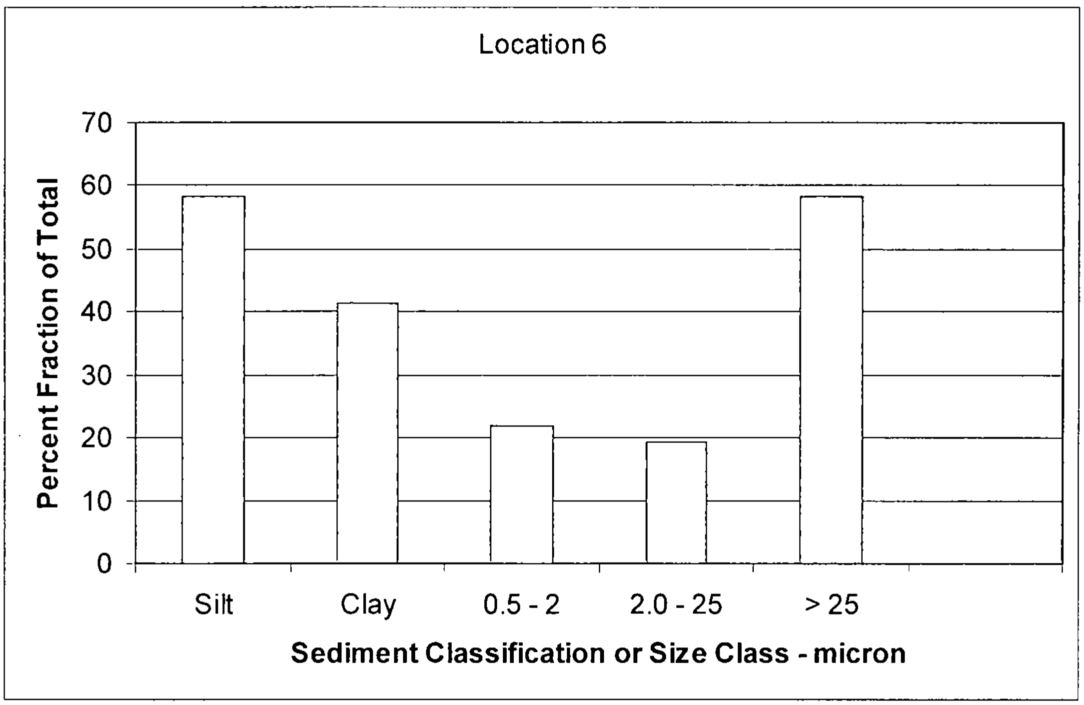

Figure 24. Suspended sediment size fractions for location 6 – average of all depths

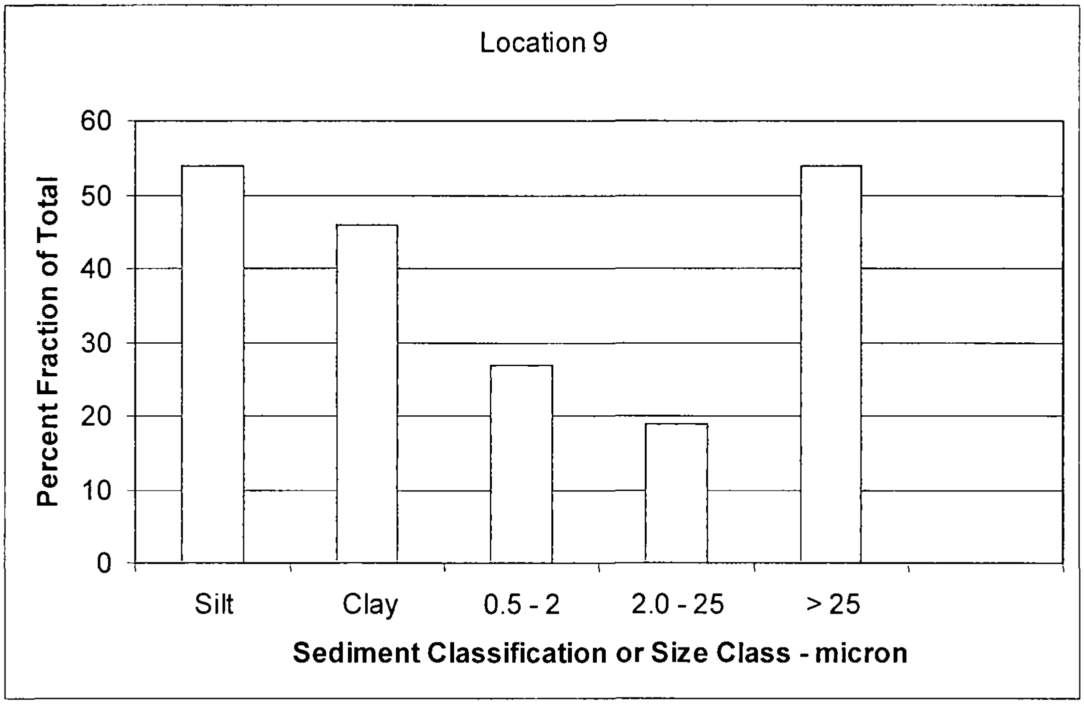

Figure 25. Suspended sediment size fractions for location 9 – average of all depths

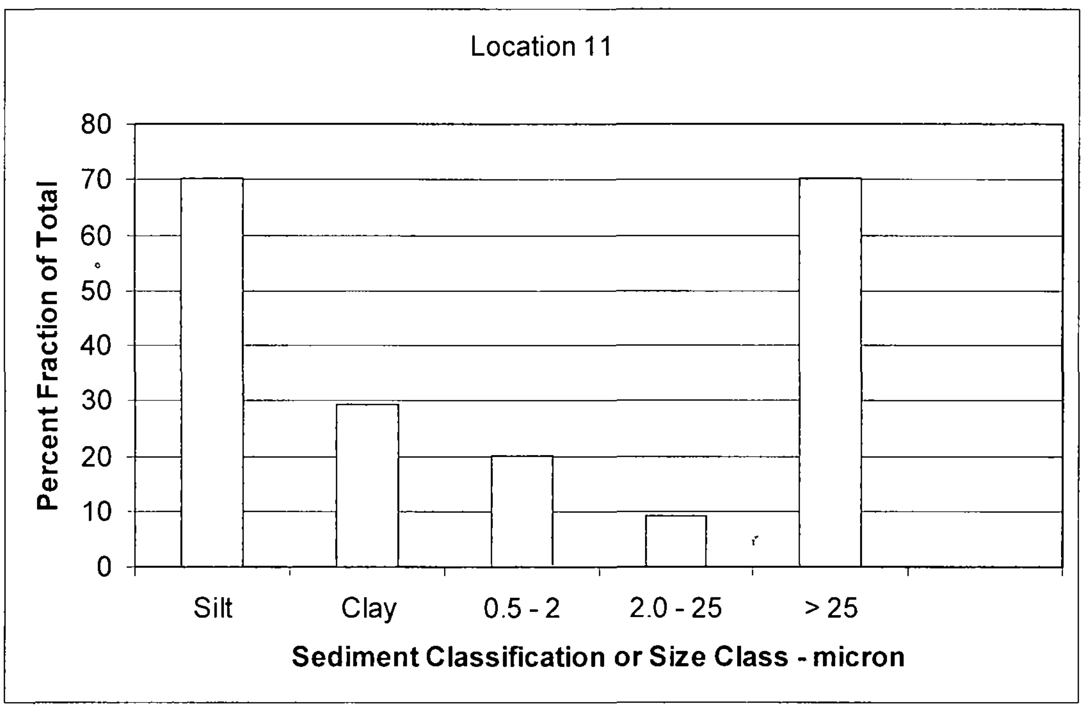

Figure 26. Suspended sediment size fractions for location 11 – average of all depths

Evaluation of the Monitored Natural Recovery (MNR) Concept for the Olin OU-2 Site

October 27, 2008

US Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
(601) 634-2371

Evaluation of the Monitored Natural Recovery (MNR) Concept for the Olin OU-2 Site

Prepared for

EPA Region 4

Prepared by

Stephen H. Scott, PhD, PE

US Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
River Engineering Branch
Sedimentation and Hydraulics Group
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October 27, 2008

Evaluation of the Monitored Natural Recovery (MNR) Concept for the Olin OU-2 Site

Introduction

The pilot project constructed by Olin Corporation is based on the concept of monitored natural recovery . This concept is based on the premise that suspended sediment load in the Tombigbee River will, over time, provide a functional natural cap over the mercury laden sediments in the 74 acre OU-2 site. The site is located off the Tombigbee River, with water and sediment exchange with the river taking place during flood events with water surface elevations (WSE) exceeding 4 feet. A berm sited at approximately 12.0 feet has been constructed around the site, with a gated structure built on the southern end of the site to control flows in and out of the site.

At a river WSE of approximately 4.0 feet, river water and sediment flow into the OU-2 site through the gated structure. Figure 1 shows the maximum inflow velocity that occurs during the rising limb of the hydrograph (at a WSE of about 5.0 feet). Where the flow constricts through the gate, the flow velocity approaches 1.0 ft/s, however, the velocity quickly drops off to less that 0.1 ft/s after entering the OU-2 site. Most of the site has velocities less than 0.01 ft/s during the inflow through the gated channel. The site will eventually fill, with the berms overtopped at a river WSE elevation of 12.0 ft. However, at a river WSE of approximately 10 feet, the Tombigbee River begins to flow into the northernmost flood plain above the OU-2 site, including the adjacent Ciba property. Thus over the WSE range of 10 – 12 feet, floodwater is entering the site from the southernmost connecting channel while the northernmost floodplains are flooding on the river side of the berm. The river water flowing through the floodplains is circulating outside the berm, and returning to the river through a ditch that runs from the Ciba property through the Olin property and eventually to the river.

At a river WSE greater than 12 feet, the berms are overtopped, and the entire OU-2 site and floodplains become hydraulically connected to the river. Figure 2 shows the peak flood velocities when the river is flowing through the floodplain and OU-2 site. The average velocity in the OU-2 site at peak flood is on the order of approximately 0.2 ft/s, with velocities on the order of 0.1 ft/s in the central and northernmost areas of OU-2. When the flood recedes to the top of the berm (WSE of 12 feet), the gate is closed on the connecting channel, and the water is held in the OU-2 site until all the suspended sediment settles out. At this time, the water is released back to the river. For smaller floods for which the WSE does not exceed 12 feet, the gate is closed at the peak of the flood in an effort to trap any sediment that may enter the system through the gate.

In summary, the sediment pathways to the OU-2 site are: 1) through the southernmost gated connecting channel for a river WSE range of 4 – 12 feet and 2) through the northernmost floodplains during river WSE greater than 12 feet. The sediment pathway through the gated structure has the most potential for directly delivering river sediment to the site. The flow from the northernmost floodplain can potentially deliver sediment, however, the flow must pass through significant floodplain vegetation at low velocities, thus there is a high potential for the fine sediments to deposit in the floodplain before reaching the site.

Tombigbee River Hydraulics and Flooding Potential

To determine the potential for the MNR concept to succeed at the Olin OU-2 site, it is necessary to thoroughly understanding the Tombigbee River hydraulics and flooding potential. An analysis was conducted on stage and flow data available from two gauging stations. The flow data were from the USGS gauging station at Coffeyville Lock and Dam upstream of the OU-2 site (46 year record), and river stage from the Leroy gauging station upstream of the site (6 year record from 2005 – 2006). The Leroy stage was converted to stage adjacent to the Olin site using regression analysis.

A useful analysis tool for determining the frequency of river stage or flow is the stage or flow duration curve (Figures 3 and 4). These plots provide an indication of how frequently a given stage or flow is exceeded, and the duration of stage or flow intervals. From Figure 3, the frequency of non-flooding river stage (< 4 feet WSE) is approximately 44 percent of the time, or approximately 161 days per year. The frequency of flood stage occurring between 4 and 12 feet (OU-2 flooding through the access channel) is approximately 34 percent or 124 days per year. The frequency of flood stage that exceed 12 feet (total basin and floodplain flooding, including pilot gate operation) is 22 percent or 80 days per year. Therefore, the stage duration curve indicates that 56 percent of the time, the Olin OU-2 basin has some potential to flood to some degree (204 days per year).

The flow duration curve (Figure 4) indicates that the median flow for the Tombigbee River is about 15,000 cfs (50 percent exceeded). Approximately 85 percent of the flows are less than 60,000 cfs and only one percent of the flows are greater than 160,000 cfs.

The Tombigbee River return flood event probability is provided in Figure 5. This plot provides the probability that a certain magnitude flood event will occur in a given year. The flood discharge probabilities range from approximately 60,000 to 310,000 cfs for the 1 year and 200 year flows respectively. Using the discharge / stage rating curve in Figure 6, the corresponding stages to the probabilistic floods are 13 ft for the one year return flood and 18 – 20 feet for the remainder of the above listed discharges. The peak stage for large floods is about 20 feet due to the extensive floodplains east of the Olin site. Note how this effect is reflected at the tail end of the stage rating curve (Figure 6) Based on these results it can be surmised that the OU-2 site will become completely flooded every year to some degree and duration. Additionally, from Figure 6, the non-flooding events that occur 44 percent of the time (<4 feet WSE) have a discharge range from about 2,000 – 20,000 cfs. The flooding events from 4 to 12 feet WSE through the access channel (occur 34 percent of the time) have discharges from about 20,000 to

55,000 cfs. The flooding events that overtop the berm and flood the entire basin and floodplain have discharges exceeding 60,000 cfs (occur 22 percent of the time).

Suspended Sediment Field Measurements

To justify the MRN application to the site, Olin collected a number of suspended sediment samples over a two year time frame, 2005 – 2005. These samples were taken at the Ciba and Olin dock locations on the river. The samples were collected with an ISCO automatic sampler set at an elevation of 6 feet. Thus the sample location within the suspended sediment profile in the river is dependent on river stage. If the suspended sediments in the river were well mixed and homogeneous in profile, this method would provide reliable data for an average total suspended solids measurement. However, on the edge of the river with lower velocities and turbulence, the suspended solids are more likely stratified in profile, thus the finer sediments (clays and fine silts) are in the upper level of the profile, while the sands and coarse silts are in the lower profile. Thus the suspended sediment samples taken in the river can only be used as an approximate total suspended sediment concentration. Figure 7 shows the suspended sediment rating curve developed from sampling data at the Ciba dock. The data from the Ciba dock is the most representative because it reflects the potential sediment load in the river that will flow into the Northernmost Olin and Ciba floodplains and ultimately the OU-2 site during a flood.

In relation to the flow analysis above, it is important to point out that 85 percent of the Tombigbee River flows will be less than 55,000 cfs (floods less than the berm elevation of 12 feet). Thus it follows from Figure 7, that for the sediment inflow condition where the berms are not overtopped, the highest concentration of suspended sediment available to the OU-2 site from the Tombigbee River will average $\leq$100 mg/l. This is an important conclusion because the flood events that do not overtop the berm can potentially deliver the highest sediment concentrations to the site through the access channel to the Tombigbee River. From the data presented above, the sediment concentrations will be relatively low. The low sediment concentrations along with the low inflow velocities to the site (Figure 1) imply that relatively low sediment concentrations will be distributed across the 74 acre OU-2 site for the smaller flood events for which the berms are not overtopped.

For the larger Tombigbee Flood events that occur for approximately 15 percent of the flows (>55,000 cfs), the berms are overtopped, and the site is inundated for a given duration. Although the potential sediment concentrations are higher (Figure 7), the water and sediment flow into OU-2 is not through the more direct inflow channel, but now flow from the northernmost floodplains into the site. Note from Figure 2 that the velocity in the Tombigbee River for these type floods is on the order of $\geq$ 3.0 feet per second, whereas the flows in the floodplain are a factor of 10 lower. This significant reduction in sediment transport capacity, as well as floodplain vegetation resistance, will significantly reduce the amount of sediment that eventually enters the OU-2 site. As shown in the following section, these large flood events have very long durations (10 – 50 days). The suspended sediment concentration in the Tombigbee River will drop to background levels in a short period of time, thus when the flood recedes, the OU-2 site will potentially have very little sediment to trap by closing the gates and holding in the water. This effect of flood duration on sediment availability to the site is explained in more detail in the section below.

Analysis of Actual Flood Event Statistics from Year 2000 Through 2006

The number of flooding events that occurred over a six year time span was evaluated. Approximately 43 flood events were documented from the stage record (see attached appendix). The events were classified as flood events if they exceeded the 4 ft WSE criteria. Of the 43 events, 14 had peak flood elevations less than the berm elevation (<12 feet). The remainder events flooded both the OU-2 site and the floodplain. In summary, the floods that enter the OU-2 site through the access channel only (4-12 feet) occurred 32 percent of the time. Sixty eight percent of the time, the berms were overtopped and the site was flooded for a given duration.

Flood event duration is an important criterion for the success of the MNR concept at OU-2. Figure 8 describes the flood event duration for all floods that exceed 12 feet (overtop.the berms). The duration of these floods ranges from 5 days to up to about 50 days for the larger, long duration floods.

The pilot gate closure occurs when the flood (river WSE) drops below 12 feet. As seen in Figure 9, the duration that OU-2 site is inundated can range from 5 – 50 days. The impact that these long duration floods have on the sediment carrying capacity of the Tombigbee River can be seen on Figures 9 and 10. These are stage hydrographs at the Ciba Dock taken during the suspended sediment sampling activities by Olin. Note that each flood hydrograph has suspended sediment values assigned to the ascending and descending legs on either side of the peak. These values represent the average ascending and descending total suspended solids measurement. It is readily apparent from these plots that the suspended sediment concentration in the river drops by approximately 55 percent over these long duration floods. These plots are for the Tombigbee River only, where flow velocities are high enough to maintain a suspended solids load.

Although the suspended solids in the OU-2 site have not been measured to date for the pilot operation, it can be reasonably assumed that the suspended solids concentration in the OU-2 lake will potentially be low when the gate is closed after a long duration flood. The reason is that the floodwaters are entering the site from the northern floodplains, thus not only has the Tombigbee River sediment supply dropped by approximately 56 percent during the long duration flood, the sediment depleted flows must now flow through a highly vegetated floodplain with a resulting drop in velocity. The end result will be very little suspended sediment delivered to the OU-2 site. As mentioned before, these types of flood events account for the majority of the flood flows that Olin is counting on to deliver sediment to the site. The other flood flows that enter the site through the access channel (flood elevations less than the berm elevation) are limited in sediment concentration.

Conclusions

Two suspended sediment delivery pathways are available for the MNR pilot operation: 1) inflow through the access channel that connects the OU-2 site to the Tombigbee River (floods < 12 ft WSE and flood durations < 5 days and 2) Long duration floods (5 to 50 days) that exceed the berm elevation height (12 feet) and flood the entire area. Both pathways are limited on the amount of suspended sediments available.

Data analyses indicate that the short term floods with water surface elevations less than 12 feet that enter through the access channel will potentially contain low suspended sediment concentrations due to relatively low flows in the Tombigbee River.

The long term floods (5-50 day duration) that enter the OU-2 site from the northern floodplain, will potentially be sediment depleted after the long flooding duration thus the sediment trapping efficiency of the OU-2 site after gate closure will be low.

Figures

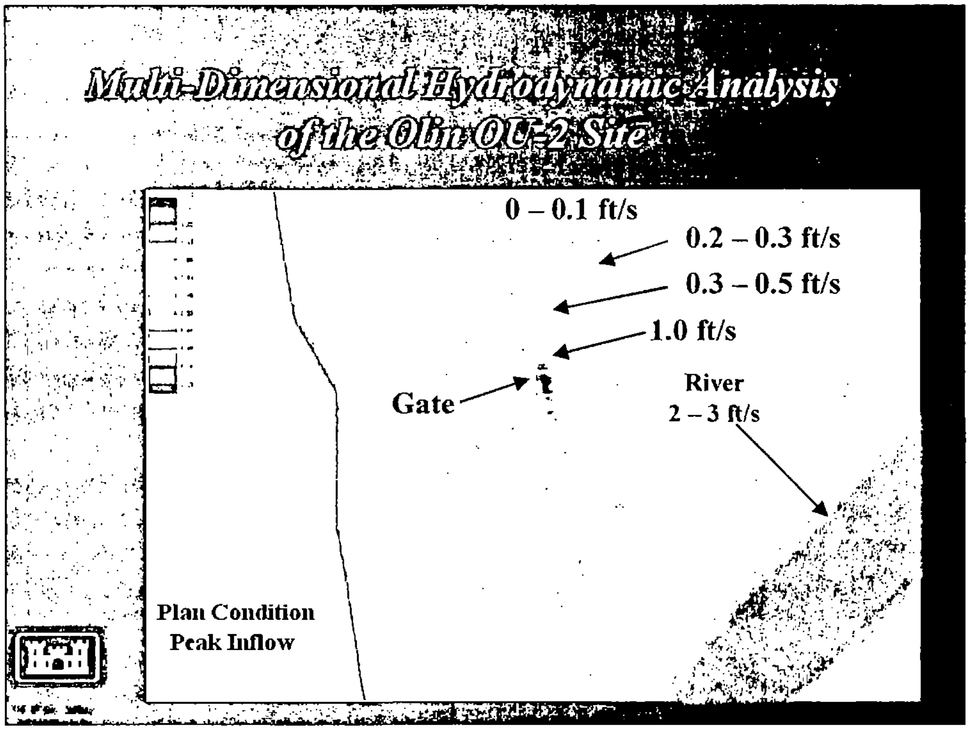

Figure 1. Peak inflow velocities into OU-2 site during flooding through access channel

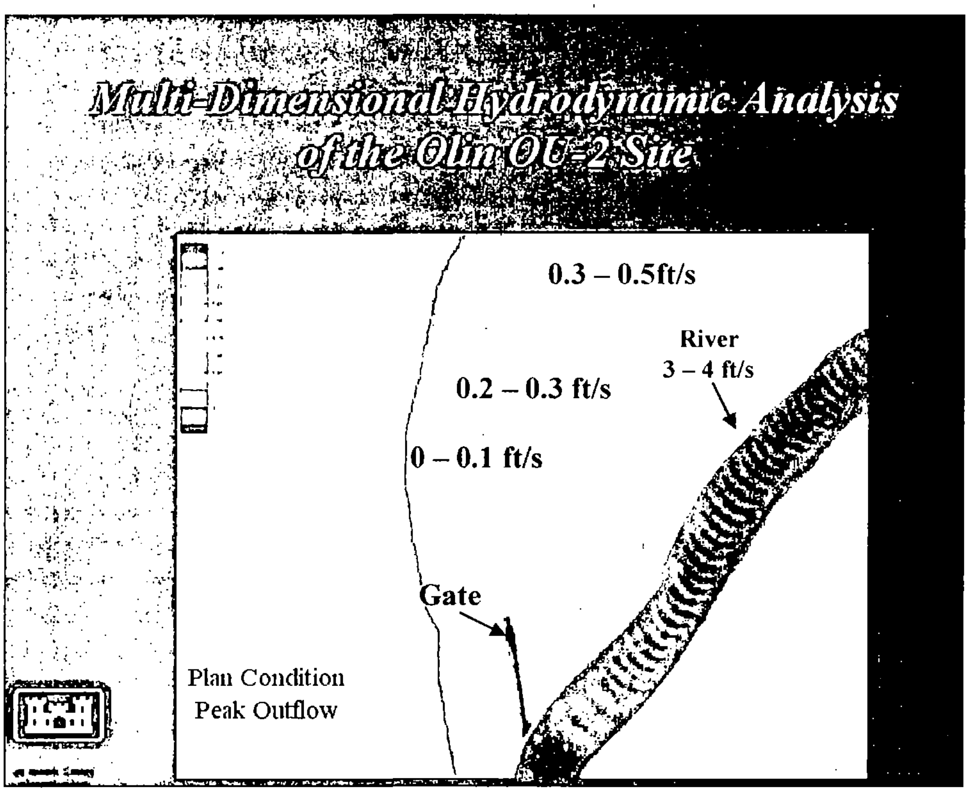

Figure 2. Flow velocity though OU-2 site during large flood with berm overtopped

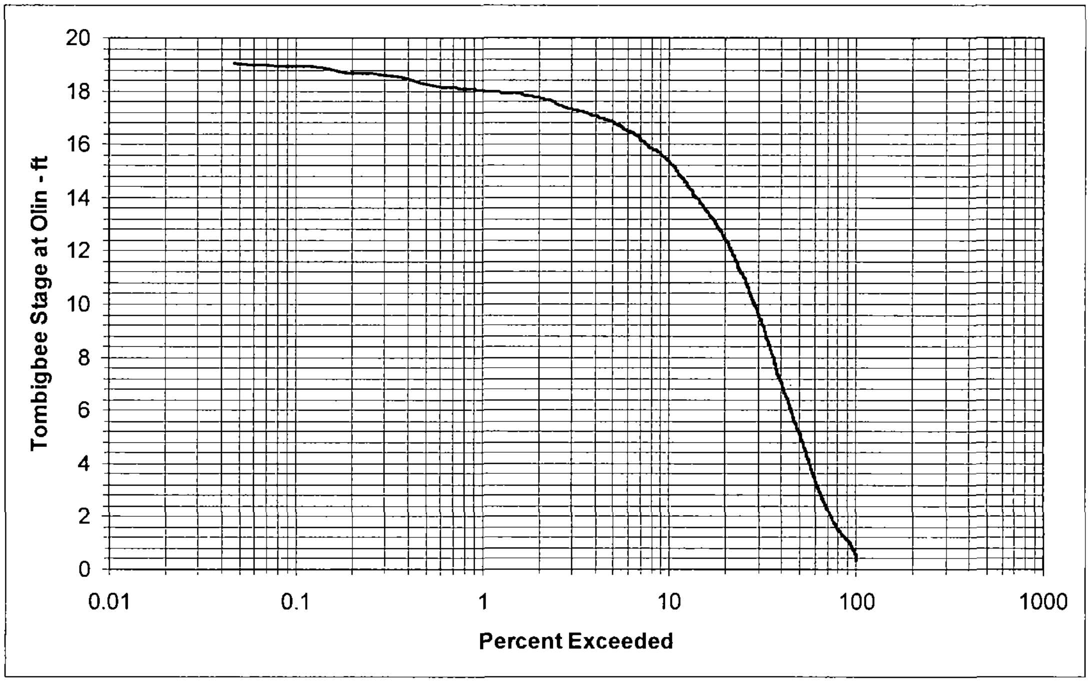

Figure 3. Tombigbee River stage duration curve

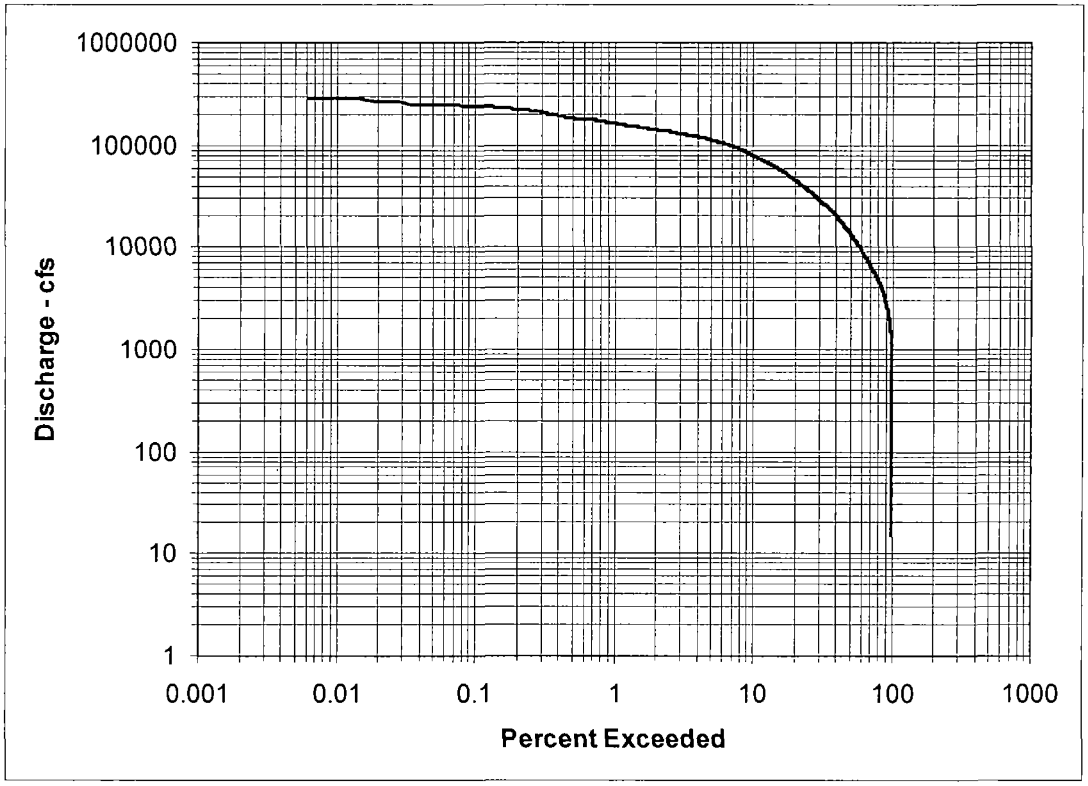

Figure 4. Tombigbee River flow duration curve

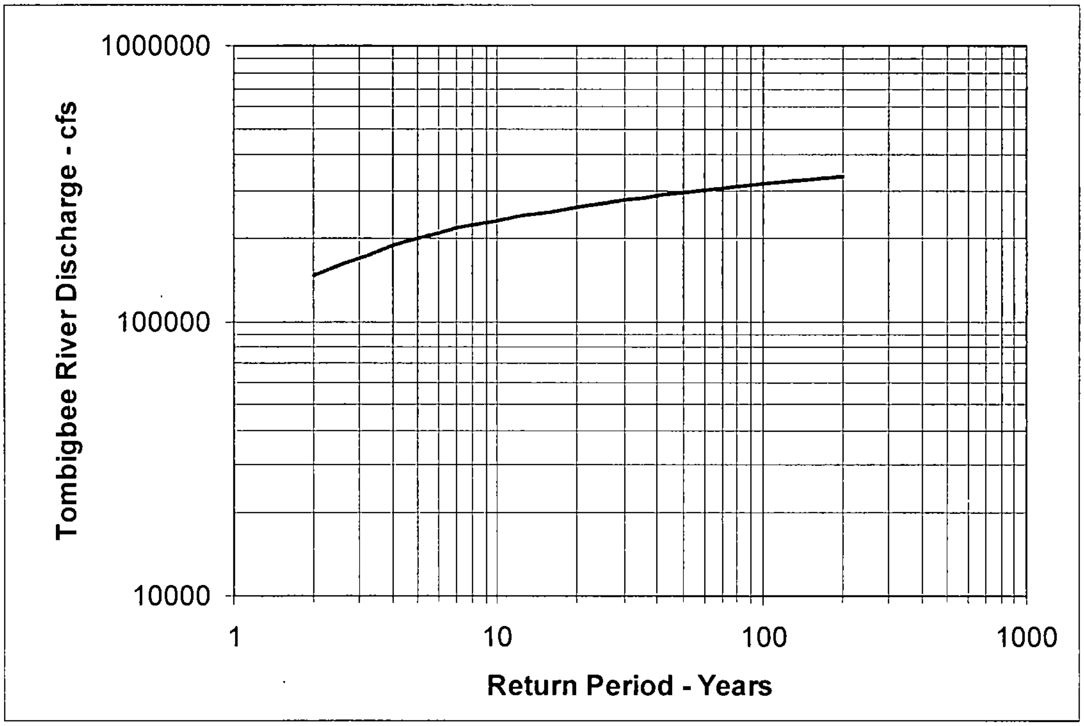

Figure 5. Return flood probability for the Tombigbee River

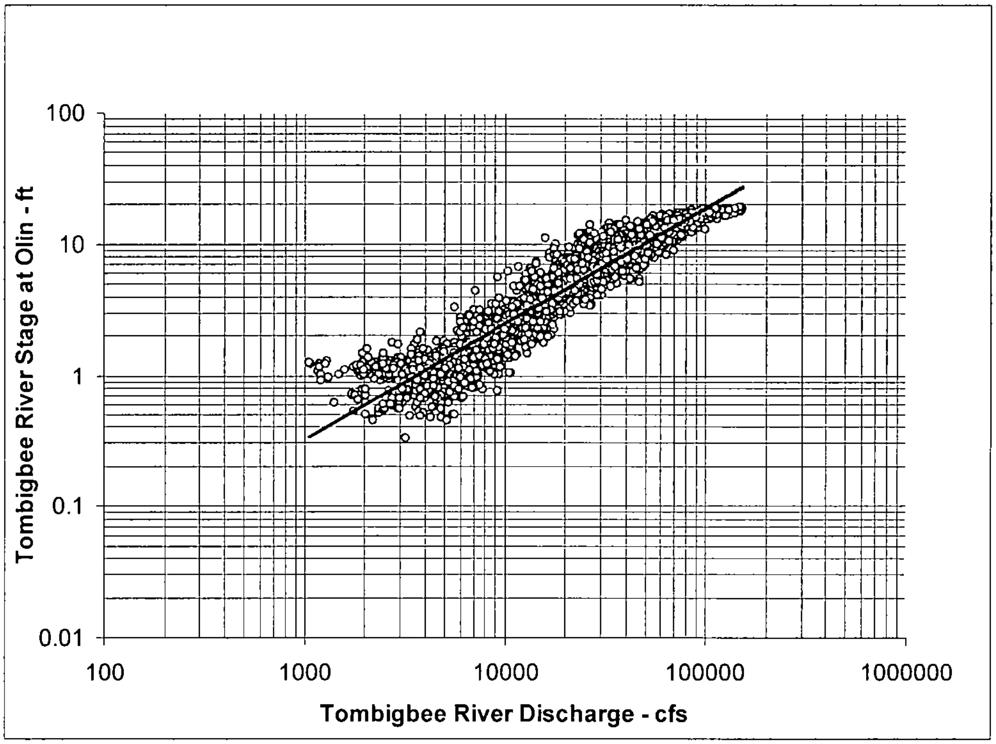

Figure 6. Stage rating curve for the Tombigbee River

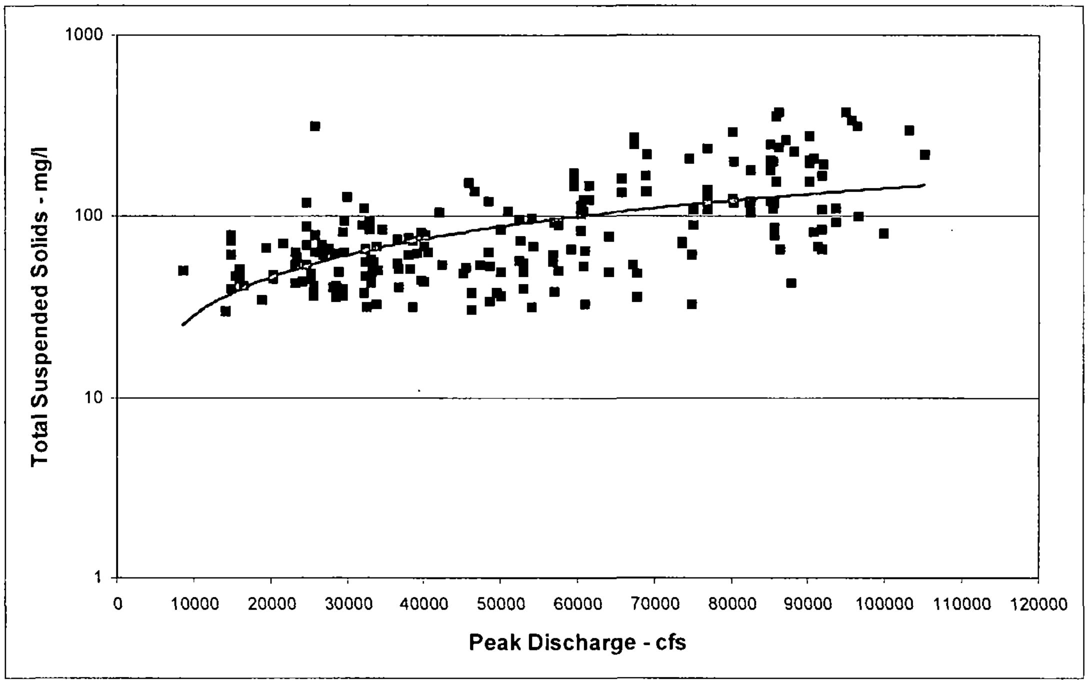

Figure 7. Suspended sediment rating curve at Ciba dock

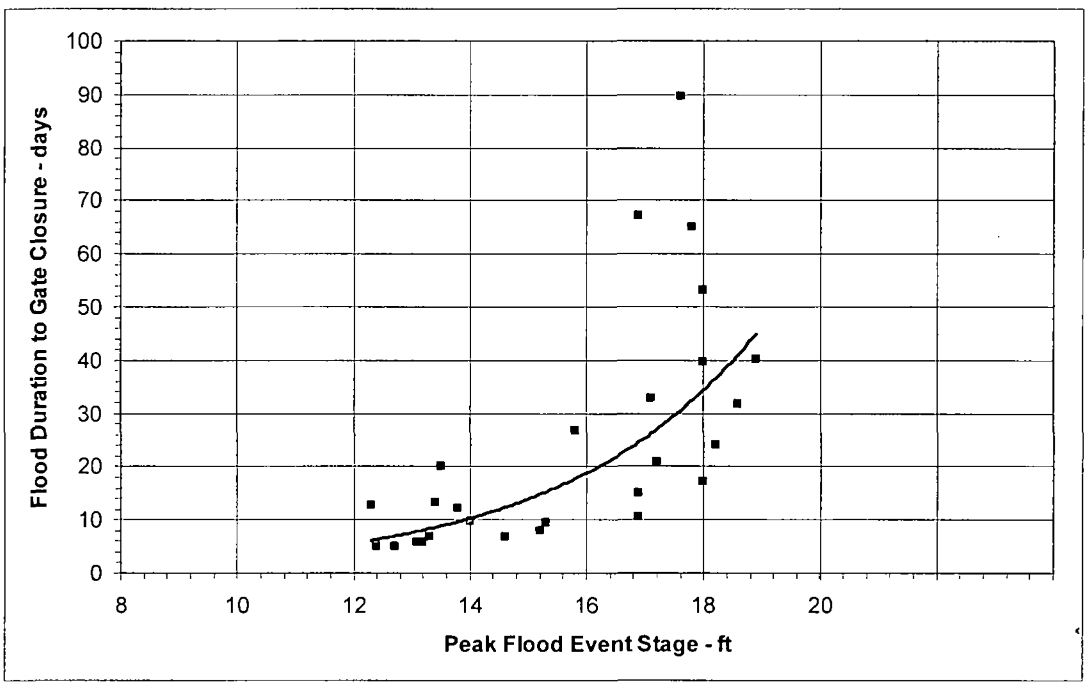

Figure 8. Flood event duration as a function of peak flood stage – duration to gate closure

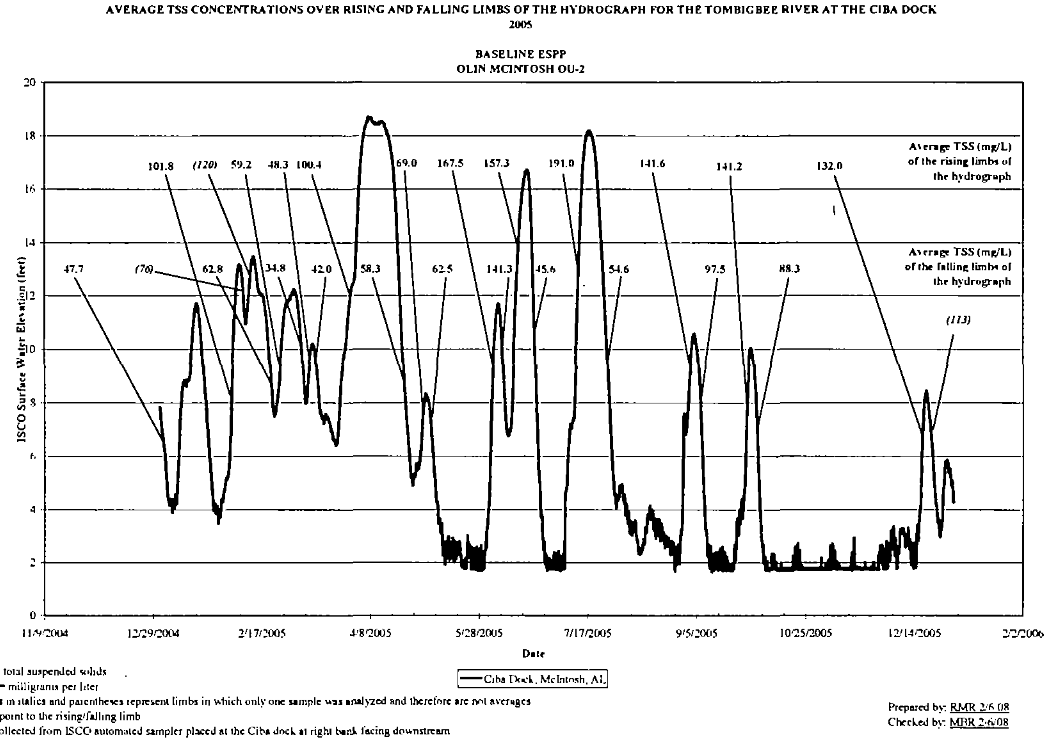

Figure 9. Suspended sediment concentration on the ascending and descending 2005 hydrograph at the Ciba dock.

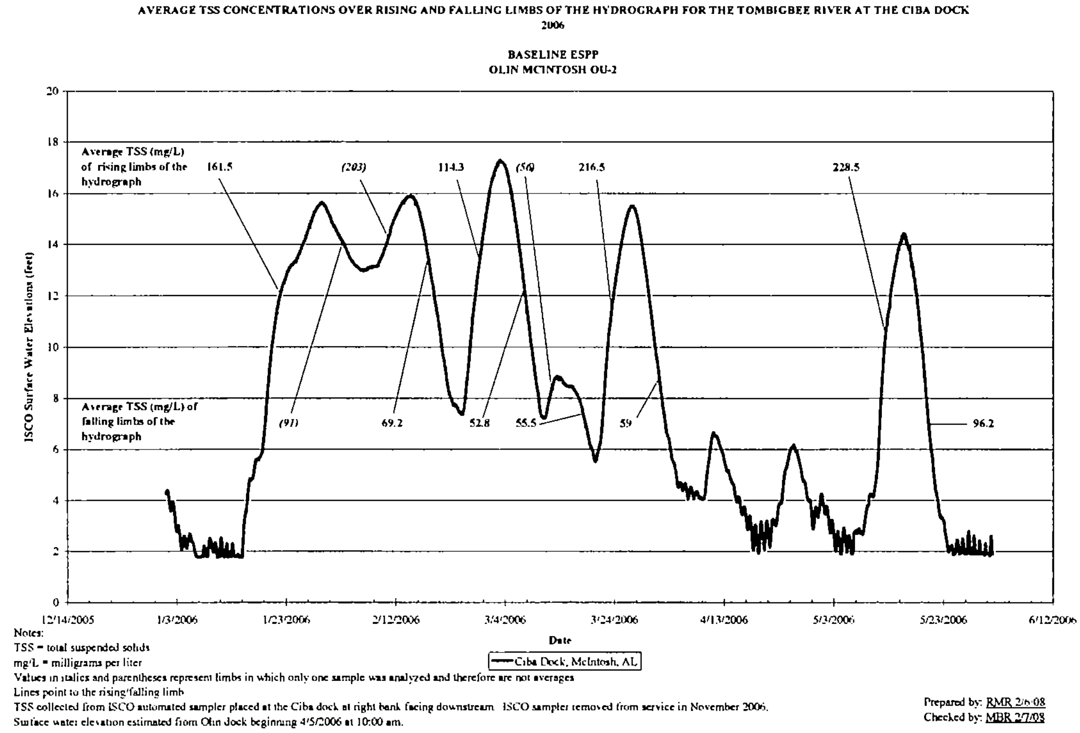

Figure 10. Suspended sediment concentration on the ascending and descending 2006 hydrograph at the Ciba dock.

Appendix

Tombigbee River Stage at Olin Dock: 2001 - 2006

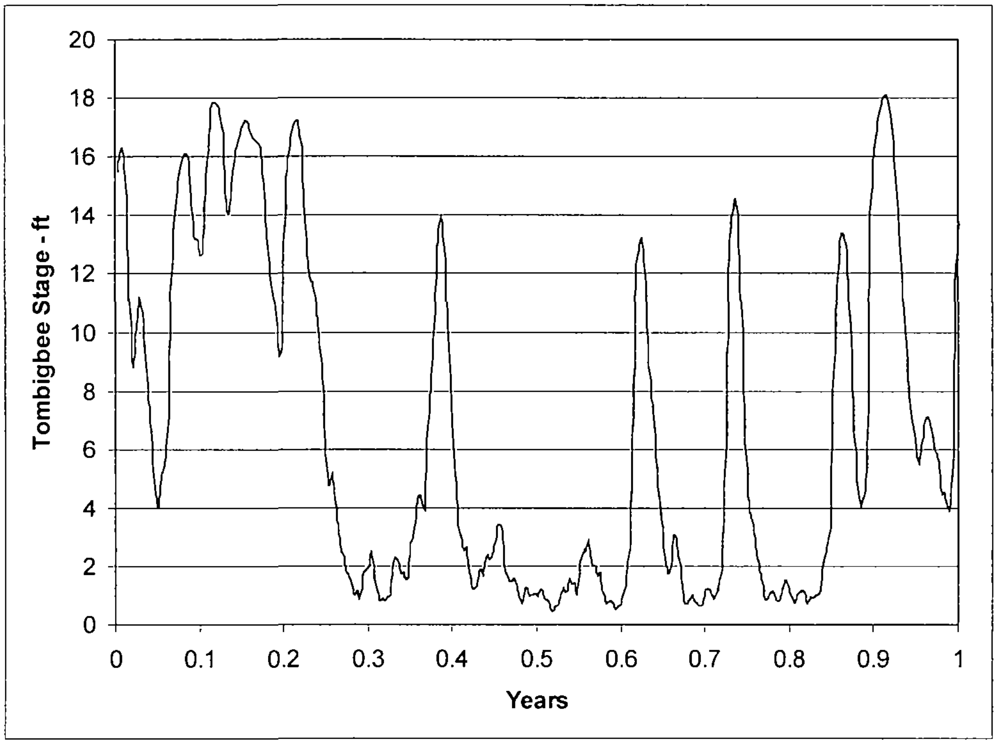

Figure 1a. Tombigbee stage at Olin 2001 - 2002

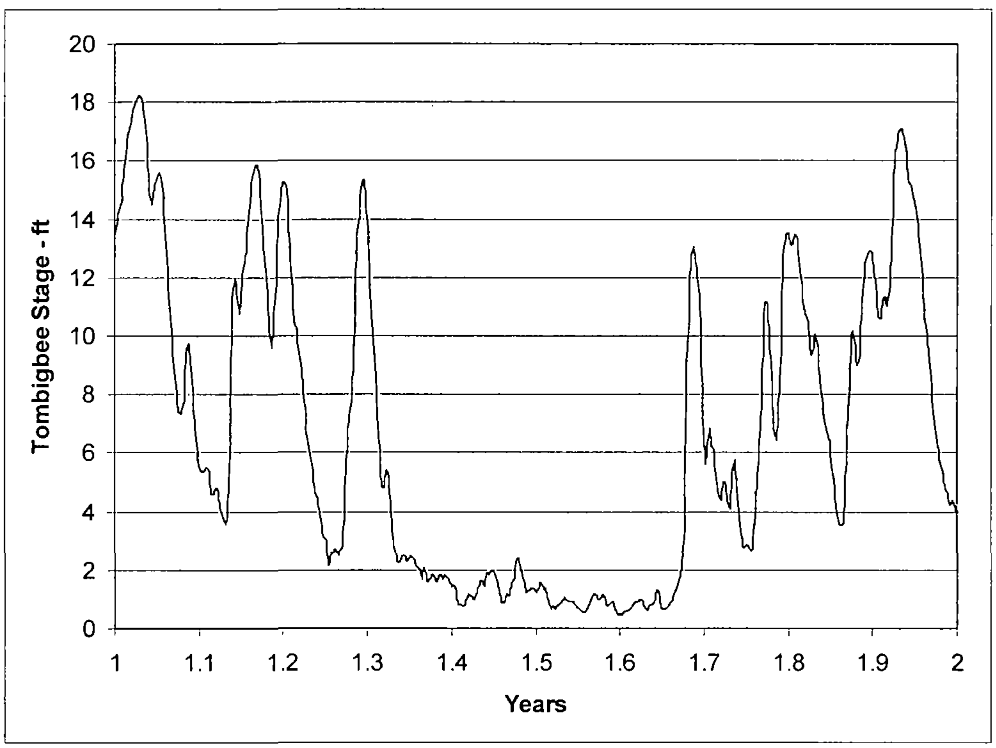

Figure 2a. Tombigbee stage at Olin 2002 - 2003

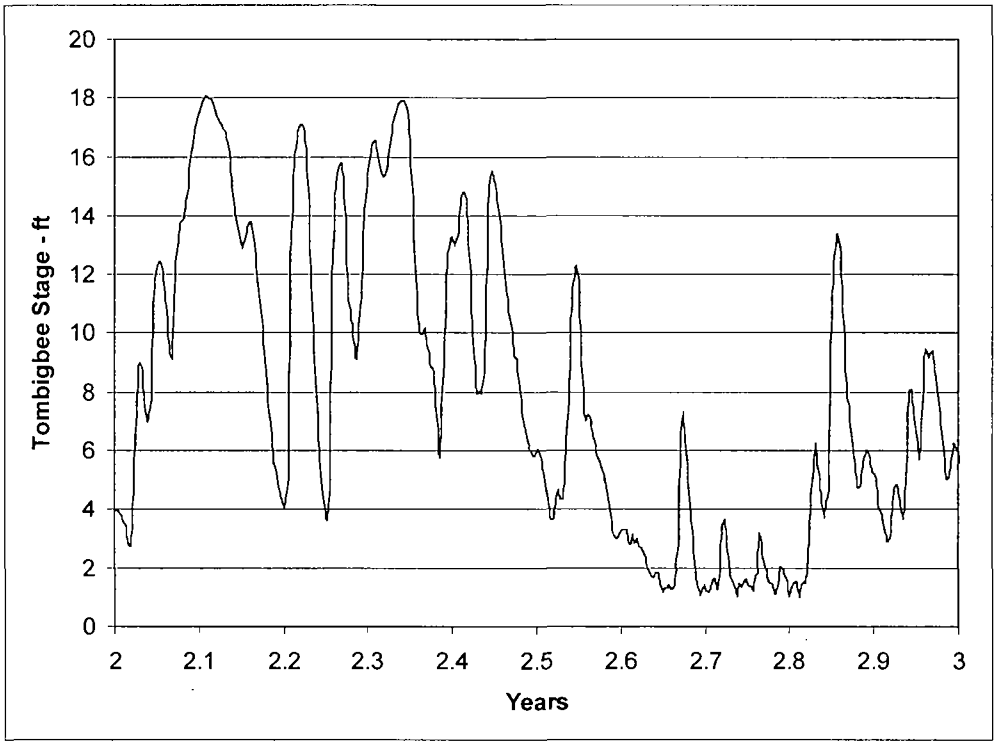

Figure 3a. Tombigbee stage at Olin 2003 - 2004

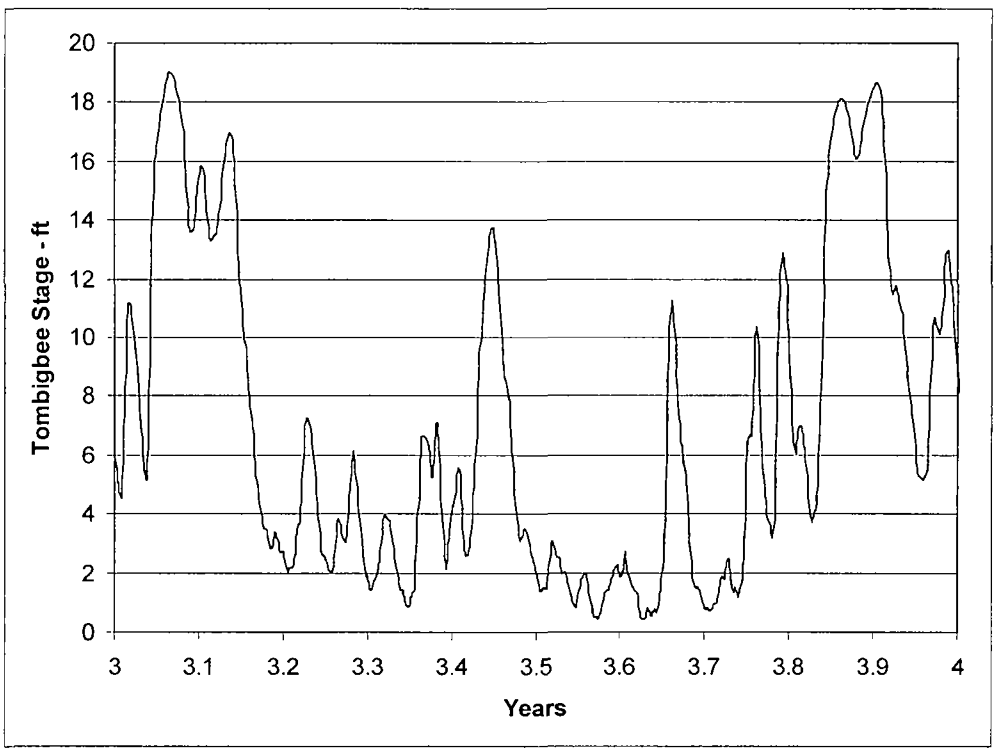

Figure 4a. Tombigbee stage at Olin 2004 - 2005

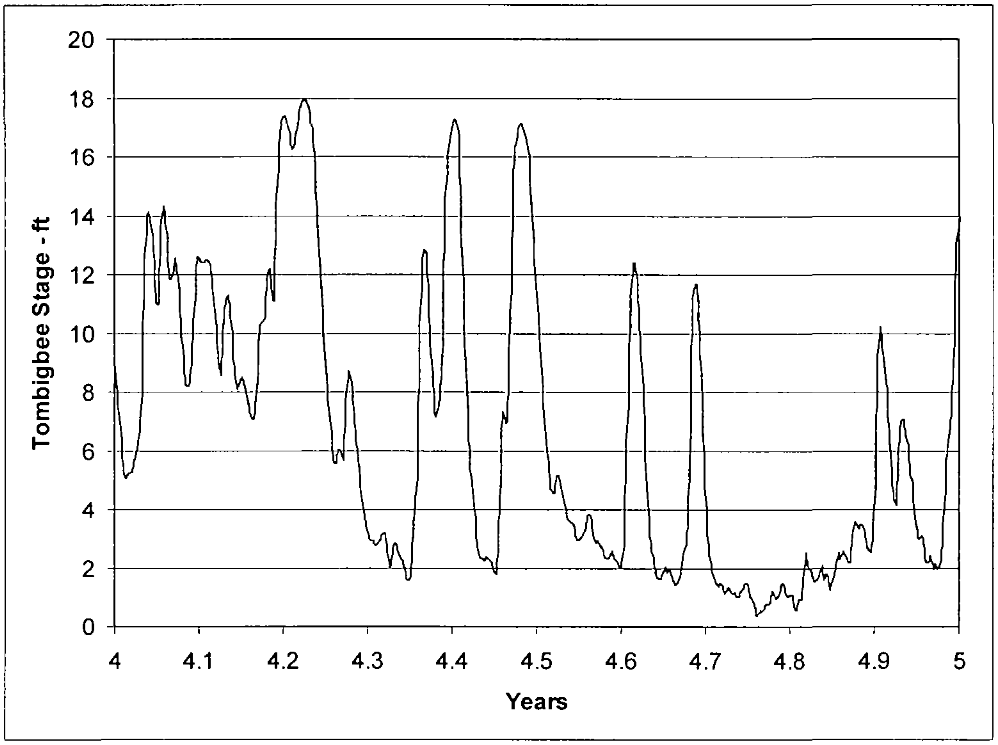

Figure 5a. Tombigbee stage at Olin 2005 - 2006

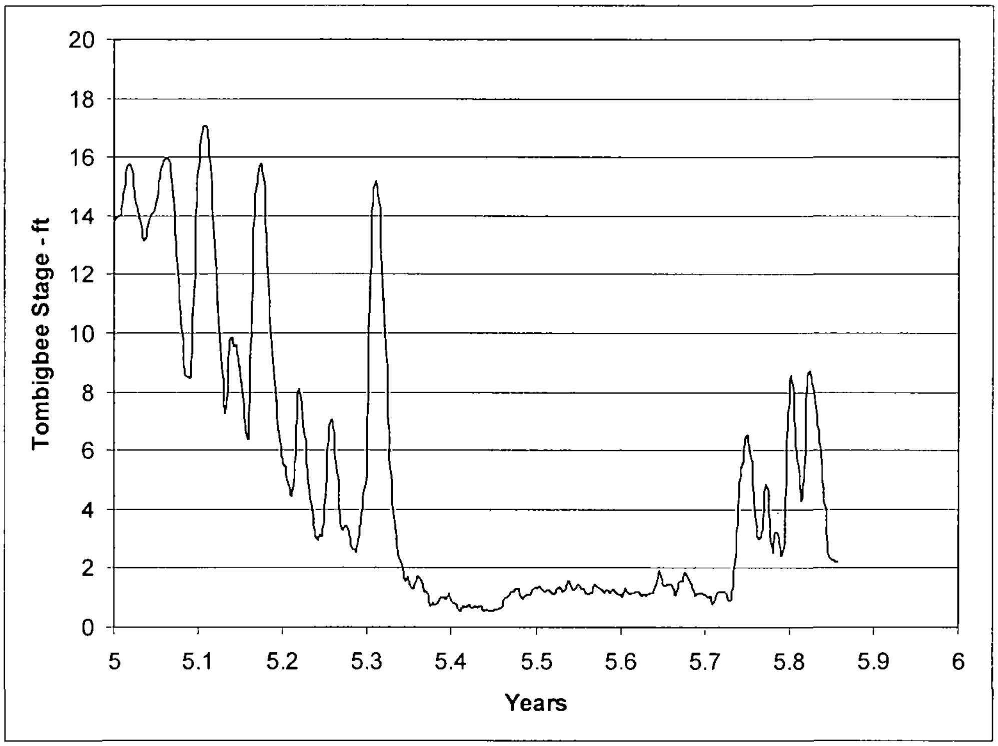

Figure 6a. Tombigbee stage at Olin 2006 - 2007